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THE ROLE OF VISUAL-SPATIAL ABILITIES IN THE PERFORMANCE OF
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THE CHANGING ROLES OF THREE VISUAL-SPATIAL ABILITIES (SPATIAL ORIENTATION, VISUALIZATION, AND PERCEPTUAL SPEED) IN THE PERFORMANCE OF GROSS MOTOR SKILLS AT SUCCESSIVE STAGES DURING THE LEARNING PERIOD WERE STUDIED. THE SUBJECTS CONSISTED OF 48 WOMEN, AGES 17 TO 24, WHO WERE EQUALLY ASSIGNED TO EITHER OF TWO SECTIONS AND SUBDIVIDED INTO THREE ROTATION GROUPS. A VARIETY OF PERFORMANCE TASKS AND PERCEPTUAL TESTS WERE ADMINISTERED. MOTOR SKILLS WERE PRESENTED AND EVALUATED. ANALYSIS OF VARIANCE PROCEDURES WERE USED TO TEST THE EFFECT OF THE TREATMENTS AND GROUPS, AND THE EFFECT OF THEIR INTERACTIONS. CORRELATIONS WERE MADE ON THE PERCEPTUAL MEASURES. FOR PERFORMANCE OF ALL SKILLS DURING THE EARLY STAGES OF PRACTICE, RESULTS SHOWED (1) SPATIAL ORIENTATION AND VISUALIZATION HAD A SIGNIFICANT EFFECT, (2) PERCEPTUAL SPEED HAD A SIGNIFICANT EFFECT, BUT NOT IN ALL SKILLS, AND (3) VISUALIZATION APPEARED TO HAVE NO APPRECIABLE EFFECT. THE SUGGESTION WAS MADE THAT AN INVESTIGATION OF THE RELATIONSHIP OF VISUAL-SPATIAL ABILITY TO IMPROVEMENT AS A RESULT OF "MENTAL PRACTICE" MIGHT BE OF VALUE. (AL)

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THE ROLE OF VISUAL-SPATIAL ABILITIES
IN THE PERFORMANCE OF CERTAIN MOTOR SKILLS

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THE ROLE OF VISUAL-SPATIAL ABILITIES IN THE PERFORMANCE OF CERTAIN MOTOR SKILLS

A

DISSERTATION

Presented to the Faculty of the Graduate School of
The University of Texas in Partial Fulfillment
of the Requirements
For the Degree of

DOCTOR OF EDUCATION

by

Loretta May Stallings, B.A., M.A.
Austin, Texas
August 1965

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In Memory of

Burns D. Goodwin, Lt. Col., U.S.M.C.

PREFACE

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Loretta M. Stallings

University of Texas
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June 10, 1965

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CHAPTER I

INTRODUCTION

Reviews of research in physical education (Cratty, 1964; Mohr, 1960) reveal that few studies have been undertaken which had as their primary aim the investigation of perceptual-motor relationships. Research on gross motor skills has been limited primarily to study of the contribution of physical abilities, such as strength and speed, to the performance of these skills. This emphasis on the physical components is understandable in view of the obvious relationship of such factors to athletic performance. Moreover, knowledge of the complex interrelationship of the sensory and motor systems is a relatively recent development. Nevertheless, neglect of the perceptual components has left incomplete the mapping of the total dimensions of performance and learning with resulting limitations on the effectiveness of training programs.

Although inferential statements have been made regarding the importance of perceptual abilities to performance in physical education activities, few studies have been conducted which clearly indicate such relationships (Cratty, 1964). Of these, studies comparing kinesthetic awareness and motor performance and studies of the relationship of visual acuity and depth perception to movement accuracy predominate. Studies investigating the role of visual space perception, other than depth perception, are notably lacking despite the fact that such abilities have been recognized as factors in motor "educability" (McCloy, 1940; McCloy & Young, 1954, p. 7).

Fitts (1951) suggested that early motor learning is primarily under visual control. If sensory stimulation is viewed as an error-correcting function of the central nervous system, the learner would be seen as having little opportunity to experience appropriate proprioceptive feedback in the early learning period when movement errors are relatively large. However, as errors become smaller through visual control, proprioceptive cues could become more effective. A recent study (Fleishman & Rich, 1963) has supported this assumption. Visual-spatial ability was shown to be significantly related to performance in the early stages of learning a two-hand coordination task. In addition, factor analyses of motor skills required of Air Force pilots (Fleishman & Hempel, 1954, 1955) resulted in the isolation of visual-spatial factors and their relationship to performance was shown to decrease as practice continued and proficiency increased. The problem remains, however, to define the role of these abilities in gross motor performance.

The purpose of this study, therefore, is to determine the relationships of specific visual-spatial abilities to the performance of different types of gross motor skills at successive stages during the learning period.

Results of the study should provide information useful in the structuring of training programs. One of the most promising uses of knowledge of the ability requirements of a motor skill has recently been demonstrated (Parker & Fleishman, 1961). Having determined from previous studies that spatial orientation and multilimb coordination were important ability requirements of a complex tracking task at specific stages of practice, the investigators developed a training program which provided the subjects with information regarding these requirements prior to and during the stages of practice where each had been shown to have a significant relationship to performance. The experimental group proved significantly superior to the control groups in both performance and learning.

Knowledge of the visual-spatial components of different gross motor skills at various stages of practice should have a similar potential.

Such knowledge might facilitate skill training in other ways as well. A teacher might use such information as a basis for selecting visual presentation methods and for arranging teaching methods in terms of the demonstrated changes in the requirements of the skill over the period of learning. In training situations involving one student or a small group of students, presentation methods might be adjusted for individual differences in these abilities.

Results of the study should provide an incentive and a basis for planning further investigations of the perceptual correlates of motor performance and motor learning. Possible areas of application include not only athletic skills, but all types of movements, rehabilitative as well as developmental.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

An historical review of spatial factors was considered requisite to the present undertaking as was an exhaustive search for studies relating these factors to motor skills. Since the present study bases its significance on the assumption that motor performance and motor learning can be "accounted for" by various ability "traits," a review of this area was also considered pertinent.

Abilities and Motor Skills

Studies which have demonstrated the specific nature of motor skills have virtually erased the traditional concept of a "general motor ability." As early as 1930, Seashore (1930), among others, established the independent nature of motor skills. Recently, Franklin Henry and his collegues (Henry & Whitley, 1960) demonstrated that tasks involving movement speed, reaction time, and strength were based primarily on factors unique to the movement. However, as Cratty (1964, p. 42) has pointed out, researchers have continued to search for "general" factors within the specificity framework. McCloy (1937) and Jones (1949), studying gross motor skills and Fleishman and his collegues (Fleishman & Ellison, 1962; Fleishman & Hempel, 1954, 1956), studying manipulative tasks, have succeeded in isolating basic factors contributing to a group of similar motor skills. Comparative examination of factor analytic studies of motor learning (McCraw, 1949), motor coordination (Cumbee, 1954), physical proficiency (Hempel & Fleishman, 1955), and psychomotor performance (Fleishman & Hempel, 1956) reveals many similar factors and suggests that there are at least some abilities basic to performance on the wide variety of tasks used as criterion variables in these studies.

McCraw (1949), in his factor analysis of motor learning, suggested that the factors involved in motor learning might be present only in a specific part of a performance and that success in an activity might depend on certain combinations of several such factors. Even earlier, Brace (1946), noting the marked variation in individual differences in ability to learn motor skills, suggested that sport-type skills and stunt-type skills seemed to require different abilities. However, knowledge of the definite ability patterns of different motor skills must be credited elsewhere.

During and following World War II, numerous studies were undertaken, primarily by the Air Force and industry, which were aimed at analyzing the task requirements of manipulative motor skills. In industry, these studies took the form of experimental manipulation of either work conditions or display design. The Air Force, however, used an individual difference approach to isolate the ability variables of the task. The results led not only to criteria for the selection and classification of personnel, but to an elucidation of the relation of abilities to performance. This work extended theories outlined earlier by Thurstone (1938) and Woodrow (1946) in the cognitive domain and by McCloy (1940) and Brace (1946) in the area of motor skills. Definitive theories have been described by Ferguson (1954) and by Gagné and Fleishman (1959). In the "ability-skill paradigm" constructed by Fleishman (1962), "ability" refers to the relatively stable traits of an individual which can facilitate performance in a wide variety of different tasks. "Skill" is more specific, referring to the level of proficiency in a particular task. The construct assumes that the abilities which different individuals possess will help predict both the rate at which specific skills requiring these abilities are learned and the final level of proficiency that is attained. More than two hundred manipulative motor tasks have been investigated in a series of interlocking studies (Fleishman, 1962). From the patterns of correlations obtained, a relatively small number of abilities were held to account for performance on this wide range of skills.

Two parallel studies (Fleishman & Hempel, 1954, 1955) showed that the ability composition of certain manipulative skills changes as practice continues and proficiency increases. These changes were demonstrated to be progressive and systematic through the learning period. In addition, factors specific to the skill were shown to increase with practice and to make up the major component of the skills late in practice. Similar changes in factor structure have been found in a gross motor skill involving batting accuracy (Allison, 1963). Thus, there is some evidence that the abilities contributing to performance early in training may be quite different from those contributing at later stages.

Visual-spatial Abilities

Psychologists have been aware of individual differences in visual imagery since the time of Galton. However, they have been more interested in the nature of the process than in its relationship to performance (Fruchter, 1954). Kroussy (1935, p. 86) defined his K factor as the ability to "obtain, manipulate and utilize visual spatial imagery." Thurstone (1938, p. 80) described his spatial factor S as "facility in spatial and visual imagery." "Visualization" was first separated from the original spatial factor in the Aviation Psychology Program during World War II (Guilford and Lacey, 1947). In a later work, Thurstone (1950) distinguished three kinds of visual-spatial abilities. S_1 was concerned with visualization of the total rigid configuration; S_2, with the flexibility of movement of parts within the total configuration; and S_3, with the ability to think about those spatial relations in which the body orientation of the observer was an essential part of the problem. He suggested that S_3 might involve kinesthetic imagery.

The Air Force studies continued to demonstrate two or more factors involved in the original spatial factor.

Guilford, Fruchter, and Zimmerman (1952) isolated two factors. Spatial relations was said to emphasize "empathic involvement and directional discrimination" (p. 55). Visualization was seen to involve "a mental manipulation of objects in space" (p. 56).

In 1952, a Symposium on Spatial Relations was sponsored by the American Psychological Association at which Zimmerman (1954) advanced an hypothesis regarding the nature of these two factors. He suggested that "spatial orientation" and "visualization" might be differentiated by their relative positions on a complex continuum of difficulty extending from perceptual speed at the one end to reasoning at the other. An individual bringing himself into alignment with an object empathically would be "spatializing"; where it was necessary to bring the object into position, a person would "visualize." Zimmerman (1953) also performed a revised rotation for Thurstone's original Primary Mental Abilities Test Battery which resulted in the isolation of a spatial relations and visualization factor similar to those identified in the Air Force studies.

A committee appointed by the Educational Testing Service (Michael, Guilford, Fruchter & Zimmerman, 1957) attempted a collation of the interpretations of visual-spatial factors. Its investigation resulted in descriptions of the abilities and recommendations for reference tests. The committee defined spatial relations and orientation as "the ability to comprehend the nature of the arrangement of elements within a visual stimulus pattern with respect to the examinee's body as a frame of reference" (p. 189). Visualization, according to the committee, requires "mental manipulation of visual objects involving a specified sequence of movements" (p. 191). A third factor, tentatively termed kinesthetic imagery, was thought to represent merely a right-left discrimination with respect to the location of the body. Recently this has been assumed to be a part of"spatial orientation."

Although high correlations between tests of "spatial orientation" and "visualization"have been noted (Buros, 1953, pp. 695, 698), the two have appeared together as separate factors in at least 20 studies (French, Ekstrom & Price, 1963, p. 38).

Cratty (1964, pp. 133-135), after reviewing factorial studies of visual-space perception, lists four factors: (a) the ability to imagine movements in two-dimensional and three-dimensional space, (b) the ability to adapt as the position of a spatial figure is changed and to predict the appearance of an object when viewed from different angles, (c) kinesthetic imagery or the ability to project oneself into a pattern and to manipulate objects mentally, and (d) the ability to compare objects in two-dimensional and three-dimensional space.

Visual-spatial Perception and Motor Skills

The only comprehensive study of visual-spatial perception and gross motor skills found was that of Donna Mae Miller (1960). One hundred and sixty-two men and women were categorized as champions, near-champions and low-skilled performers in specific sports activities. The perceptual test battery included tests of perceptual speed, spatial orientation, visualization, closure and static balance. The main differences found by Miller between outstanding performers and low-skilled persons were in balance, depth perception, and closure. Of these, static balance was the only single predictive measure and a selected battery was only slightly more predictive than balance alone. The significant correlation found between depth perception and balance led Miller to suggest that these tests have a visual element in common and that vision is an important factor in maintaining balance. Miller concluded that there are measurable differences in the visual-perceptual abilities of performers of varying levels of skill and that players of championship ability are more likely to possess superior visual-perceptual abilities than those of low gross motor skill.

Attempts have been made to isolate the basic factors of space perception in manipulative motor skills. Typical of these efforts is a factor analytic study carried out by Fleishman and Hempel (1954). Scores were obtained at eight different stages of practice on a complex coordination task involving adjustments of an airplane stick and rudder in response to visual signal patterns. Not only did the number of factors decrease as practice continued, but there was a shift in the nature of the factors. During the initial stages, nonmotor factors, including spatial relations, visualization, and perceptual speed, contributed about 46 percent of the variance as compared to 30 percent contributed by motor factors. Later in learning, motor factors contributed about 75 percent of the variance and nonmotor factors accounted for only 11 percent.

A parallel study (Fleishman & Hempel, 1955) confirmed these results. In a visual discrimination reaction task, spatial relations decreased from 36 percent initially to 11 percent in the terminal stages. The investigators suggested that learning the spatial characteristics of a task is a minimal but necessary requirement for achieving progress. However, once the spatial relationships of the task are learned, other factors assume increasing importance.

Fitts (1951) suggested that visual control is important while an individual is learning a new motor skill and that, as performance becomes habitual, proprioceptive feedback or "feel" becomes more important. This hypothesis has received support from a recent study (Fleishman & Rich, 1963). The investigators studied, through an individual difference approach, the relative roles of kinesthetic and visual-spatial ability in a two-hand coordination task. Visual-spatial ability showed a significant relationship to task performance only early in learning and kinesthetic sensitivity only late in learning. They concluded that those individuals with the greater capacity for utilizing visual information make more rapid progress in the early stages of motor learning.

For two decades, studies on the effects of "symbolic rehearsal" or "mental practice" have been reported in educational and psychological journals. Basically, the technique involves "thinking through" the movement pattern of a skill or visualizing oneself performing the skill for a specified number of "practice" periods. The technique has been shown to improve performance in a wide variety of motor skills. In a ring-tossing experiment, Twining (1949) reported 36.2 percent improvement in 21 days of practice. Vandal, Davis and Clugston (1943) found that free-throw shooting was improved 43 percent. Similar improvement in shooting accuracy was reported by Clark (1960). Mental practice has also improved retention of a maze habit (Sackett, 1935), smoothness of performance in bowling (Waterland, 1956), and endurance as measured by number of sit-ups (Kelsey, 1961). In a recent study (Smith & Harrison, 1962) comparing visual, motor, mental, and guided practice on speed and accuracy of performance on a stylus coordination skill, visual and mental practice improved accuracy whereas motor practice and guided practice did not. However, mental practice has usually been shown to be less effective than physical practice, and the point of interest recently has been to determine what enables an individual to profit from this type of experience. Suggestions have ranged from motivation and "games ability"

(Start, 1960, 1962) to prior motor experience and ability to visualize (Clark, 1960). Early studies on the use of "symbolic rehearsal" (Bean, 1939; Sackett, 1935; Shaw, 1940), using introspective analysis, report the predominant use of visual imagery. Clark's (1960) subjects, also using introspective analysis, reported increased ability to visualize the technique and a more acute sense of quickly recognizing mistakes by the final test. Clark suggests the existence of a strong relationship between ability to visualize and improvement experienced.

That "mental practice" may be, in fact, a method of achieving visual control in the early learning period is suggested by a study (Gagné & Foster, 1949) in which practice on a pictured representation of a motor task was substituted for mental practice. The paper-and-pencil task required marking X's in the same relative spatial positions as those of a motor reaction panel. The subjects afterward completed 60 trials on the actual motor task. Not only was practice on the "pictured" task more effective than preliminary training on the motor task itself, but the amount of transfer up to the 30th trial increased directly with the number of "pictured" trials. The greatest increase occurred through the 16th trial, with less increase thereafter. The results were consistent with other studies on the effectiveness of a variety of types of observations including direct observation of a demonstration, observation of motion pictures, verbal guidance, and mental practice. The investigators suggested that the transfer was due to learning the relative spatial characteristics of the task. It is noteworthy that no reference to this study, published in 1949, was found in the literature on mental practice.

The results of two other studies suggest the existence of a "general" spatial factor contributing to the performance of certain motor skills. Woodward (1943) found that practice in one industrial task aided performance on a second when the movement patterns were similar. More recently, Cratty (1962a) found a spatial factor present in performances of tasks involving various sizes of mazes. Practice on a stylus maze transferred to performance on a large locomotor maze when the spatial patterns of the mazes were geometrically similar. Cratty found his results inconsistent with "neurogeometric theory" (Smith & Smith, 1962) and with the findings of studies which point to the independence of fine and gross motor skills.

One of the most comprehensive studies of visual space perception and movement was undertaken by Karl Smith (Smith & Smith, 1962). Based on the effects of displaced and delayed visual feedback on human movement, Smith constructed a "neurogeometric theory of motion" which conceives of sensory feedback as an intrinsic regulation process in movement. Specificity in motor skills is accounted for by the fact that visual-motor integration for each of three different movement components (posture, transport, and manipulation) occurs at different integrative levels of the nervous system. Underlying the theory is an extensive series of studies involving the use of a television camera directed at the performance of various handwriting and drawing tasks. The performer is prevented from seeing his own movements except through a monitor. Experimental manipulation of the camera to produce either spatial or temporal displacement of feedback resulted in profound disruption of visual-motor integration as measured by performance accuracy and learning rate. In addition to emphasizing the interdependence of visual-spatial perception and movement, the results were held to be consistent with "neurogeometric theory."

CHAPTER III

NATURE OF THE STUDY

Review of the literature reveals several questions which remain unanswered. Some of these lie within the scope of the present study and are reviewed in this chapter; others must await future investigation.

Basic to the assumptions of this study is the generality versus specificity question. Are there one or more "general" spatial factors which contribute to performance on several motor skills, or must all motor skills be dismissed as too specific to warrant the search for such factors? The specificity concept has been crystallized in Smith's "neurogeometric theory of motion" (Smith & Smith, 1962) and Henry's "neuromotor memory drum theory" (Henry, 1960). The basis of the controversy seems to lie in the definition of a motor skill. While Henry's studies have contributed to an understanding of rather direct motor acts, his experiments have involved primarily simple arm movements requiring reaction time and movement speed but excluding the need for spatial accuracy. In addition, Cratty's transfer studies (1962a, 1962b) seriously challenge the high-specificity theories as do the results of the factor analyses of manipulative motor skills carried out by Fleishman (1962).

What is the role of perceptual speed in gross motor skills? The suggestion has been made that it may be a highly important factor in motor performance.[1] Perceptual speed has been isolated in at least two factor analyses of manipulative motor skills (Fleishman & Hempel, 1954, 1956) but its relationship to gross motor skills has not been established.

Miller (1960) investigated visual-perceptual differences among individuals rated as champions, near-champions and low-skilled persons in specific sports activities. Although her test battery included tests of perceptual speed, spatial orientation, and visualization, none of these was predictive of skill level. While failure to find significant differences may be attributable to the type of test used to measure the abilities,[2] the question remains whether or not visual - spatial abilities are related to performance of specific gross motor skills at certain stages of practice. If they are, there are implications for teaching methods even if the abilities are not predictive of final performance level.

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[1] Kelley, P. Personal communication, July, 1964. Also, see McCloy and Young, 1954, p. 7 and Dinnerstein and Lowenthal, 1962.

[2] See Cratty, 1964, p. 135.

Miller's study also indicates that between two groups, one composed of extremely skilled individuals and the other of low-skilled performers, significant differences in at least one visual-perceptual ability (depth perception) do exist. Identification of finer relationships, such as determining the percentage of a skill that is "attributable" to perceptual accuracy, is lacking in studies of gross motor skills.

Purpose

The purpose of this investigation, therefore, is to determine the role of spatial orientation, visualization, and perceptual speed in the performance of different gross motor skills at successive stages during the learning period.

The specific objectives of the investigation are stated in terms of the following hypotheses: (a) that, early in learning, spatial orientation and visualization have a significant effect on performance, (b) that the relationship of spatial orientation and visualization to performance progressively decreases during the period of practice, (c) that spatial orientation and visualization have a significant effect on performance immediately following a two-week break in the practice schedule, (d) that the motor skills vary in their visual-spatial requirements, and (e) that perceptual speed has a significant effect on performance throughout the period of practice.

Assumptions

Fleishman's (1962) "ability-skill paradigm" considers ability variables, inferred from individual difference measurements, as parameters of the learning function. The implication that individual differences in ability are solely quantitative is questionable. Therefore, an important assumption underlying this investigation is that motor performance is dependent upon the extent to which the learner possesses the component ability "traits" required by a skill. A related assumption is that the ability requirements of a skill change over the period of practice, since this observation has been based on the results of factor analytic studies (Allison, 1963; Fleishman & Hempel, 1954, 1955).

Additional assumptions of this study are (a) that a substantial part of gross motor performance, even in the early stages of learning, is dependent upon the adequacy of the motor response mechanism, (b) that different gross motor skills vary greatly in their ratio of motor to nonmotor requirements, (c) that, normally, early motor learning is primarily under visual control, (d) that significant differences in visual-spatial perception exist among many levels of performers, and (e) that perception of static two-dimensional patterns distinguishes perception of movement in three-dimensional space.

Definitions

Spatial Orientation

In this investigation, the term "spatial orientation" means the ability to perceive visually the position and configuration of objects in space with the observer himself as reference point. Operationally, it is defined by performance on the Card Rotation Test (Copyright ETS).

Visualization

In this investigation, the term "visualization" means the ability to transform the visual image of spatial patterns mentally into other arrangements. Operationally, it is defined by performance on the Surface Development Test (Copyright ETS).

Perceptual Speed

In this investigation, the term "perceptual speed" means the rapidity of visual form discrimination. Operationally, it is defined by performance on the Identical Pictures Test (Copyright ETS).

CHAPTER IV

METHODS

Subjects

The subjects for this investigation consisted of 42 freshman and sophomore women, ages 17 to 24, enrolled in required physical education at The George Washington University. Seventy-six volunteers for the study were obtained by contacting individuals in required physical education classes during the semester immediately preceding the study. Forty-eight persons were selected to participate. Selection criteria were (a) that the subjects be relatively unfamiliar with the type of motor skills used in the study, (b) that they be designated free from limiting physical defects by the University physician, (c) that their record in physical education class for the semester immediately preceeding the study give evidence of regular attendance, and (d) that a wide range of physical ability, as evidenced by physical education grades, be represented.

Only those subjects who attended every testing session, as scheduled, were included in the analysis. Forty-four of the 48 subjects thus completed the three and one-half month schedule. One subject completed the schedule because of her interest in the study but was eliminated from the analysis because she was found to have a limiting scoliosis that was unnoted in the required physical examination. Another student was eliminated due to the requirements of the analysis of variance design selected. Motivation, as evidenced by the interest and cooperation of the subjects, continued high throughout the study despite the routine nature of the motor skill testing. Discussion of research techniques and individual plotting of motor test scores helped to maintain interest.

Instruments

Perceptual Tests (Appendix A)

The selection of the perceptual abilities to be investigated was based on the review of literature and on the specific hypotheses to be tested. The perceptual tests used in the study were paper-and-pencil tests which were developed, recommended, and supplied by the Educational Testing Service (ETS) for testing the specific perceptual abilities under investigation. In each case, the test was adapted by ETS from one used in repeated factor studies. It was felt that "this could be done without altering the factor composition of the tests" (French, _et al_., 1963, p. 3). To the extent that this goal was achieved, the tests are assumed to have the factorial validity of the original tests. In addition, the tests were selected by ETS so as to be "as factorially pure as possible for the intended factor" (French, _et al_., 1963, p. 2).

All of the tests used were recommended by ETS as suitable for grades nine through 16. In addition, each test was divided into two separately timed parallel parts to permit proper estimation of reliability. In the present investigation, test reliability was estimated in each case by a split-half correlation corrected by the Spearman-Brown formula with n=2 (Guilford, 1956, p. 452). At least two days elapsed between the administrations of each of the three tests.

Card Rotations Test (Copyright ETS). This test, suggested by Thurstone's _Cards_, was used to measure spatial orientation. Each of the 28 items of the test gives a drawing of a card cut into an irregular shape. To its right are six other drawings of the card either rotated by different amounts or turned over. The examinee indicates which drawings show the card not turned over by marking a plus or a minus on each of the six drawings. Subjects are allowed four minutes for each of the two parts of the test. The score is the number of cards marked correctly minus the number marked incorrectly. In this study, test reliability was .88.

Surface Development Test (Copyright ETS). Adapted from Thurstone's Surface Development, this test was used to measure visualization. The examinee is asked to imagine or visualize how a piece of paper can be folded to form a certain "solid" object. Diagrams are presented which can be folded, mentally, on dotted lines to form the object pictured next to them. The subject indicates which of the lettered edges on the object are the same as the numbered edges on the diagram. Five such identifications are required for each of the 12 diagrams of the test. Six minutes are allowed for each of the two parts of the test. The subject's score is the number of correct identifications minus one-fourth of the number incorrect. In this study, test reliability was .94.

Identical Pictures Test (Copyright ETS). Adapted from tests originally by Thurstone, this test was used to measure perceptual speed. For each of the 96 items, the examinee checks which of five numbered geometrical figures or pictures is identical to a given figure at the end of the row. The subject is allowed one and one-half minutes for each of the two parts of the test. The test score is the number of items marked correctly minus one-fourth of the number marked incorrectly. In this study, test reliability was .88.

Motor Skills

The criteria for the selection of the motor skills were (a) that they be relatively novel for the population to be sampled, (b) that they require a minimum of strength, power, endurance and flexibility, and (c) that one be a stunt-type and one a sport-type skill. Pretesting was carried out to arrive at the desirable number of trials, the specific instructions to be given, and the method of scoring. Each subject was given two trials on each skill every session. Test reliability for the subjects of the study was determined in each case by a test-retest correlation between the final two sets of four trials. Three days elapsed between each set of four trials.

Speed Pass. The subject stands behind a line parallel to and eight feet from a solid, smooth wall. On the signal "begin" from the timer, she passes a volleyball against the wall with a two-hand chest pass, catches the ball and continues passing as rapidly as possible until she has hit the wall 10 times with 10 passes. The test is timed from the instant the first pass hits the wall until the 10th pass hits the wall. The subject's score for each trial is recorded in tenths of seconds. The scores on the final tests, using the average of the best trial each session, had a test-retest reliability of .90. Reliability of the timer was estimated at .97 in prestudy sessions.

Balance Beam Stunt. The beam, four inches wide, is elevated to a height of four inches from the floor and surrounded by protective mats. The subject performs a series of six maneuvers: walk forward three steps pivot turn, walk backward three steps, arabesque, standing front scale, and jump turn. The score on each trial is zero to nine points as determined by the judge on the following basis: (a) one point for each of the six maneuvers performed correctly, and (b) one point each for overall impression of balance, continuity (flow) of movement, and posture. A maneuver is judged incorrect if the subject (a) fails to perform it within three seconds of the completion of the previous maneuver, (b) steps from the beam, (c) fails to achieve a position approximately parallel to the beam on the standing front scale, (d) touches the beam with her free foot while moving from the arabesque to the scale, (e) fails to make a complete half-turn on the jump or pivot, or (f) fails to maintain the arabesque and scale for at least three seconds. Each point is tallied by the judge on a hand counter. Scores on the final tests, using the average of four trials, had a test-retest reliability of .90. Reliability of the judging, as estimated in prestudy sessions, was .87.

Underhand Throw. In this test, a regulation basketball goal and net are used, and official basket height and foul line distances are maintained. A volleyball is used in order to decrease the strength requirement and increase the novelty of the skill. The subject shoots a two-hand underhand free throw for basket from behind the free-throw line. She recovers her ball after each of five throws. Each throw is scored on the following basis: (a) three points if the basket is "made" and the ball touches neither the rim nor the backboard, (b) two points if the basket is "made" but the ball touches the rim or backboard, (c) one point if the basket is missed but the ball touches the rim (including the backboard and rim), and (d) no points if the basket is missed and the ball fails to hit the rim. The subject's score for each trial is the sum of the scores recorded for each of the five throws of the trial. Scores on the final tests, using the sum of four trials, had a test-retest reliability of .72. Reliability of the scoring, as estimated in prestudy sessions, was .98, using an intraclass correlation for the eight scorers as an indication of reliability (Guilford, 1956, p. 281).

Procedure

Rotation methods, specific tests and testing techniques were established with a prestudy group in January. Assistants were trained and the reliability of scorers, judge and timer was determined in prestudy sessions.

The actual study was conducted during the Spring Semester 1964-65. Those persons who were selected to participate in the study were scheduled for special classes to meet from 12:00 to 1:00 and from 1:00 to 2:00 on Monday and Friday each week. Two sections were required to accomodate the 48 subjects of the study. Twenty-four subjects were assigned to each section according to their available time.

The first two weeks of the semester were used to administer the perceptual tests and to assign subjects to their rotation groups. The purpose of the study was explained and the specific instructions to be followed (Appendix B) were reviewed in detail.

After spending one session "walking through" the rotation and reviewing testing procedures for the motor skills, the subjects began the testing schedule on February 26th, and continued twice each week for 12 weeks. Following a two-week break for Spring Recess, they continued for an additional eight sessions.

Rotation Schedules (Appendix E)

Within each section, subjects were assigned randomly to one of three groups, arbitrarily designated as A, B, and C for the 12:00 section and D, E, and F for the 1:00 section. Within each of these groups, subjects were assigned a number from one to eight. Thus, each subject was uniquely identified (e.g., A-1, D-5, etc.).

Order of performance on the three motor skills was varied from day-to-day by systematically rotating the groups. The order in which individuals within groups performed on each of the skills was also varied. Since four different baskets were used, and since backboards are known to differ in their rebound qualities, subjects were rotated from day-to-day on their basket assignments. All rotation schedules for each session were provided the subjects on the back of each day's scorecard (Appendix D).

Assistants

A member of the physical education faculty was paid to demonstrate and judge the balance beam stunt. A graduate assistant was paid to demonstrate and time the speed pass, and the investigator demonstrated the underhand throw. The same persons were used in both sections throughout the study. Student volunteers were used to score the underhand throw and to record for the timer and judge. All assistants were trained during prestudy sessions conducted in January and were given specific instructions prior to the study (Appendix C). Reliability of the scorers, timer and judge was established prior to the study.

Presentation of Motor Skills

The method by which a motor skill is presented would seem to be an important factor in learning the spatial relationships of the skill. In the present study, each skill was presented to the subjects in as similar a manner as possible. At every testing session, each skill was demonstrated once (one trial) to each group immediately prior to testing the group on that skill. No explanation was given other than that included in the Test Directions (Appendix B) and assistants were instructed not to give corrections since both explanations and corrections could be expected to have differential effects on performance. Specific steps were taken to prevent subjects from viewing any performance other than that of the demonstrator.

CHAPTER V

ANALYSIS OF DATA

Procedure

The primary purpose of this study is to investigate the role of visual-spatial abilities in the performance of three gross motor skills at successive stages of practice. Considered also are the effects of these abilities on overall performance of the skills.

While the initial proposal for this study called for treatment of the data by means of correlations of perceptual scores with motor performance measures at each stage of practice, the specific hypotheses which developed from the review of literature requires information in addition to that which can be derived from such correlations. Accordingly, an analysis of variance design was selected which would test these hypotheses.

Use was made of the University of Texas Computation Center and of the Computer Program Library of the School of Education for both the analyses of variance and the correlations.

Analysis of Variance Design

The two-factor "between-within" analysis of variance design, designated by Lindquist (1953, p. 267) as Type I, was used for the analysis of data. In this study, Linquist's A (treatment) factor consists of the stages of practice on the motor skill, as represented by 10 blocks of four trials each; his B (groups) factor consists of the subjects of the study dichotomized at the median on one of the perceptual measures. Since three independent variables (perceptual measures) and three dependent variables (motor skills) are being studied, nine separate analyses of variance problems were computed. The computer program used for these problems (A V G M) yields an F-ratio and its probability for (a) the main effect of treatments, (b) the main effect of groups, and (c) the interaction effect. The last two of these are pertinent to the purpose of this study.

Main effect of groups. The F-ratio for groups tests the null hypothesis that the population mean for each group, averaged over the treatment levels, is the same. Assuming no interaction, the test may be regarded as a test of the null hypothesis for any and all treatment levels (Lindquist, 1953, p. 213). In this case, a significant F indicates that there is a significant difference in the performance of the groups at each stage of practice. When a significant interaction exists, the only conclusion that can be made is that there is a significant difference in the average performance of the group over the period of practice.

Interaction effect. The interaction F-ratio tests the null hypothesis that the difference between group means for corresponding treatments is the same for all treatment levels (Lindquist, 1953, p. 138). In the case of a significant interaction F, any statement regarding the effect of the perceptual dichotomy on performance of the skill must be qualified by reference to the particular stage of practice involved. Unfortunately, however, a significant interaction F does not indicate where the interaction exists; individual or multiple comparison of groups means are required.

Comparison of group means. In the present study, the assumption is made that the only interactions of practical importance to this investigation are those which would be reflected in a change in the significance of the difference between group means at some stage or stages during practice. Therefore, in those problems which show a significant interaction, nine (k-1) comparisons were made (Lindquist, 1953, p. 272), one each at the first through the ninth stages of practice. While a nonsignificant interaction would, normally, permit the assumption that the difference between the performances of the "high" and "low" groups is independent of any particular stage of practice on the criterion motor skill, the interaction F-test is not very sensitive to an interaction which characterizes only a small part of the table (Lindquist, 1953, p. 210). Thus, the fact that total interaction proves nonsignificant does not rule out the possibility that such interaction exists. It is therefore permissible to compare means within the table when these comparisons are planned in advance (Edwards, 1960, p. 148). In the present study, the hypothesis that visual-perceptual abilities affect performance in the early stage of learning (but not necessarily at the later stages) makes necessary comparisons which might reveal differences lost in the averaging process of the interaction calculation. It was also hypothesized that stage seven would be a critical point since it followed a two-week break in the practice schedule. Accordingly, in those problems with nonsignificant interaction F-ratios, three comparisons of group means were made, one each at stages one, seven, and ten.

Correlations

With the use of the computer program for Pearson product-moment correlations (C O R R), performances on each of ten trials on each motor skill were correlated with scores for the subjects on each of the perceptual measures. The t-test upon which the r-table is based tests the null hypothesis that the population correlation is zero. A comprehensive discussion of the interpretation that may be given a correlation coefficient is presented by Guilford (1956, pp. 145-148).

Level of Significance

Lindquist (1953, p. 68) has suggested setting the .01 level of significance for exploratory investigations. However, as Cratty (1964, p. 135) has noted, tests of space perception involve tasks evaluating the facility to manipulate static figures in two-dimensional space. It is assumed that if the perceptual tests more closely approximated the dynamic space perception required in motor skills, a higher level of significance would be achieved. The .05 level of significance was established for the present study since tests of dynamic space perception are not available.

Results

Analyses of Variance

The results of the nine analyses of variance problems are presented in Tables 1 through 9. Figures 1 through 9 consist of performance curves for groups formed by dichotomizing the 42 subjects of the study on the perceptual measures. While the figures do not, in themselves, provide a basis for analysis, they present, graphically, the observed differences in the sample and can be used together with the analyses of variance to aid in interpretation. The sample means used to plot the curves and to compute the comparison F-ratios are presented in Appendix F. To facilitate use of the tables and figures, the analyses of variance and performance curves for each problem have been assigned parallel numbers.

Each of the two-factor problems consists of an analysis of variance with the perceptual dichotomy as one factor (G) and the stages of practice on the motor skill as the other factor (T). The interaction is represented in the tables by the symbol "T X G." In those problems showing a significant interaction, the comparisons of group means are represented by the symbol "C" with the subscript indicating the stage of practice at which the comparison was made. In those problems with nonsignificant interaction F-ratios, C_1 indicates a comparison made at stage one; C_2, a comparison made at stage seven; and C_3, a comparison made at stage 10.

The reader is reminded that each stage of practice represents four trials on the motor skill, the first two trial measures having been taken at the Friday session one week, and the latter two at the following Monday session. The break in the horizontal axis for the performance curves between stages six and seven represents a two-week break in the practice schedule due to the Spring Recess.

Problem 1: Spatial Orientation and Speed Pass (Table 1 and Figure 1). While the overall effect of perceptual grouping is obviously not significant ($F < 1.00$), this must be qualified in view of a significant interaction F of 2.03. Comparisons of group means indicate significant differences between groups at stages one, two, and three and F-ratios progressively decreasing from 12.26 at stage one to less than 1.00 at stage six. The performance curves, together with the comparison F's, indicate that the "high" group regained a significant superiority at stage seven, following the two-week break in the practice schedule. This superiority was lost again at stages eight and nine (F < 1.00).

Problem 2: Spatial Orientation and Balance Beam Stunt (Table 2 and Figure 2). Since the comparison of group means fails to discredit a nonsignificant interaction F of 1.01, the main effect of perceptual grouping (F = 7.77) can be said to be significant throughout the period of practice, independent of any particular stage. Examination of the performance curves indicates that the "high" group maintained superiority.

Problem 3: Spatial Orientation and Underhand Throw (Table 3 and Figure 3). With a significant F-ratio of 2.49, attention is focused on the comparison of group means. An F of 15.86 is significant at stage one. Differences at the other stages are not significant and the F-ratio for groups is less than 1.00. Interpretation of these results must be made in consideration of the variability of the underhand throw test from stage to stage.

Problem 4: Visualization and Speed Pass (Table 4 and Figure 4). The F-ratios for interaction, comparisons and groups do not even approach significance.

Problem 5: Visualization and Balance Beam Stunt (Table 5 and Figure 5). A nonsignificant interaction F of less than 1.00 is not discredited by examination of group means. However, given significant differences between groups at stages one, seven and ten with F's of 8.98, 10.34, and 9.17 respectively, the overall nonsignificant effect of groups (F = 2.40) cannot be generalized to all stages. The only statement that can be made is that the average difference between groups over the period of practice is not significant.

Problem 6: Visualization and Underhand Throw (Table 6 and Figure 6). As in Problem 2, the F-ratios for interaction, comparisons and groups are all nonsignificant. Examination of the performance curves indicates that the "low" group of the sample maintained a variable superiority. Interpretation of these results must be made in light of this variability.

Problem 7: Perceptual Speed and Speed Pass (Table 7 and Figure 7). The interaction F-ratio for this problem is less than 1.00. The comparisons of group means are significant at all three stages tested, with F's ranging from 10.6 to 15.68. However, the F-ratio for groups (3.41), while approaching significance ($p = .07$), does not reach the established level.

Problem 8: Perceptual Speed and Balance Beam Stunt (Table 8 and Figure 8). The significant interaction F of 1.93 is not reflected in a change in the significance of the differences between group means, all differences being significant. However, the comparison F-ratios range from 5.51 to 8.89 in stages one through four and from 22.06 to 31.54 in stages five through nine. The F-ratio of 6.89 ($p < .05$) for groups indicates that the perceptual dichotomy has a significant effect on overall performance of the skill. Examination of the performance curves shows that the "high" group maintained superiority throughout the period of practice, with observed differences becoming progressively larger as practice continued.

Problem 9: Perceptual Speed and Underhand Throw (Table 9 and Figure 9). Neither the interaction F of 1.57 nor the F-ratio for groups (< 1.00) approaches significance. These results must be considered in terms of the demonstrated variability of the underhand throw measures.

Table 1

Analysis of Variance for Data of Problem 1 (Spatial Orientation and Speed Pass)

Source	SS	df	MS	F	p
Between-Subjects	1058.8501	41			
G	11.1720	1	11.1720	<1.00	--
error (b)	1047.6781	40	26.1920		
Within-Subjects	386.9970	378			
T	173.2888	9	19.2543	34.0820	<.05
T × G	10.3292	9	1.1477	2.032	<.05
C_1	7.2093	1	7.2093	12.7621	<.05
C_2	6.0207	1	6.0207	10.6580	<.05
C_3	4.1400	1	4.1400	7.3287	<.05
C_4	.7203	1	.7203	1.2746	>.05
C_5	.2919	1	.2919	<1.00	--
C_6	.1733	1	.1733	<1.00	--
C_7	2.2407	1	2.2407	3.9665	<.05
C_8	.3087	1	.3087	<1.00	--
C_9	.1155	1	.1155	<1.00	--
error (w)	203.3790	360	.5649		
Total	1445.8471	419			

Table 2

Analysis of Variance for Data of Problem 2 (Spatial Orientation and Balance Beam Stunt)

Source	SS	df	MS	F	p
Between-Subjects	288.7610	41			
G	47.0006	1	47.0006	7.7760	<.05
error (b)	241.7604	40	6.0440		
Within-Subjects	642.3290	378			
T	553.0983	9	61.4554	254.2240	<.05
T × G	2.2054	9	.2450	1.0140	>.05
C_1	4.2765	1	4.2756	17.6900	<.05
C_2	7.9727	1	7.9727	32.9859	<.05
C_3	5.2868	1	5.2868	21.8734	<.05
error (w)	87.0253	360	.2417		
Total	931.0900	419			

Table 3

Analysis of Variance for Data of Problem 3
(Spatial Orientation and Underhand Throw)

Source	SS	df	MS	F	p
Between-Subjects	5225.4786	41			
G	22.4024	1	22.4024	<1.00	--
error (b)	5203.0762	40	130.0769		
Within-Subjects	4223.5000	378			
T	457.2405	9	50.8045	5.1580	<.05
T × G	220.6690	9	24.5188	2.4900	<.05
C_1	156.2190	1	156.2190	15.8616	<.05
C_2	2.3814	1	2.3814	<1.00	--
C_3	3.4283	1	3.4283	<1.00	--
C_4	22.8816	1	22.8816	2.3233	>.05
C_5	14.9037	1	14.9037	1.5132	>.05
C_6	7.7154	1	7.7154	<1.00	--
C_7	5.3571	1	5.3571	<1.00	--
C_8	3.4283	1	3.4283	<1.00	--
C_9	5.3571	1	5.3571	<1.00	--
error (w)	3545.5905	360	9.8489		
Total	9448.9786	419			

Table 4

Analysis of Variance for Data of Problem 4

(Visualization and Speed Pass)

Source	SS	df	MS	F	p
Between-Subjects	1061.0196	41			
G	28.8619	1	28.8619	1.1190	>.05
error (b)	1032.1577	40	25.8039		
Within-Subjects	387.1770	378			
T	174.7669	9	19.4185	33.5810	<.05
T × G	4.2393	9	.4710	<1.00	--
C1	1.6800	1	1.6800	2.9051	>.05
C2	.9450	1	.9450	1.6341	>.05
C3	.8001	1	.8001	1.3835	>.05
error (w)	208.1708	360	.5783		
Total	1448.1966	419			

Table 5

Analysis of Variance for Data of Problem 5

(Visualization and Balance Beam Stunt)

Source	SS	df	MS	F	p
Between-Subjects	288.7610	41			
G	16.3629	1	16.3629	2.4030	>.05
error (b)	272.3981	40	6.8100		
Within-Subjects	642.3290	378			
T	553.0983	9	61.4554	251.6530	<.05
T × G	1.3164	9	.1463	<1.00	--
C1	2.1935	1	2.1935	8.9824	<.05
C2	2.5253	1	2.5253	10.3411	<.05
C3	2.2407	1	2.2407	9.1757	<.05
error (w)	87.9143	360	.2442		
Total	931.0900	419			

Table 6

Analysis of Variance for Data of Problem 6

(Visualization and Underhand Throw)

Source	SS	df	MS	F	p
Between-Subjects	5225.4786	41			
G	32.5929	1	32.5928	>1.00	--
error (b)	5192.8857	40	129.8221		
Within-Subjects	4223.5000	378			
T	457.2405	9	50.8045	4.8980	<.05
T × G	31.9071	9	3.5452	<1.00	--
C1	6.8828	1	6.8828	<1.00	--
C2	22.8774	1	22.8774	2.2054	>.05
C3	9.5225	1	9.5225	<1.00	--
error (w)	3734.3524	360	10.3732		
Total	9448.9786	419			

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Table 7

Analysis of Variance for Data of Problem 7

(Perceptual Speed and Speed Pass)

Source	SS	df	MS	F	p
Between-Subjects	1061.0196	41			
G	83.3486	1	83.3486	3.4100	>.05
error (b)	977.6710	40	24.4418		
Within-Subjects	387.1770	378			
T	174.7669	9	17.4185	33.2950	<.05
T × G	2.4478	9	.2720	<1.00	--
C1	9.1476	1	9.1476	15.6852	<.05
C2	5.8685	1	5.8685	10.0626	<.05
C3	7.5432	1	7.5432	12.9342	<.05
error (w)	209.9623	360	.5832		
Total	1448.1966	419			

Table 8

Analysis of Variance for Data of Problem 8

(Perceptual Speed and Balance Beam Stunt)

Source	SS	df	MS	F	p
Between-Subjects	288.7610	41			
G	42.4339	1	42.4339	6.8910	<.05
error (b)	236.3271	40	6.1582		
Within-Subjects	642.3290	378			
T	553.0983	9	61.4554	259.9190	<.05
T × G	4.1120	9	.4569	1.9320	<.05
C1	1.6013	1	1.6013	6.7737	<.05
C2	1.3031	1	1.3031	5.5123	<.05
C3	2.1032	1	2.1032	8.8968	<.05
C4	1.7180	1	1.7180	7.2673	<.05
C5	5.2154	1	5.2154	22.0618	<.05
C6	7.1253	1	7.1253	30.1409	<.05
C7	7.4582	1	7.4582	31.5491	<.05
C8	7.2093	1	7.2093	30.5000	<.05
C9	6.4838	1	6.4838	27.4272	<.05
error (w)	85.1187	360	.2364		
Total	931.0900	419			

Table 9

Analysis of Variance for Data of Problem 9

(Perceptual Speed and Underhand Throw)

Source	SS	df	MS	F	p
Between-Subjects	5225.4786	41			
G	24.2881	1	24.2881	<1.00	--
error (b)	5201.1905	40	130.0298		
Within-Subjects	4223.5000	378			
T	457.2405	9	50.8045	5.0470	<.05
T × G	142.5929	9	15.8437	1.5740	>.05
C1	14.8800	1	14.8800	1.4783	>.05
C2	1.1666	1	1.1666	<1.00	--
C3	59.5214	1	59.5214	5.9133	<.05
error (w)	3623.6666	360	10.0657		
Total	9448.9786	419			

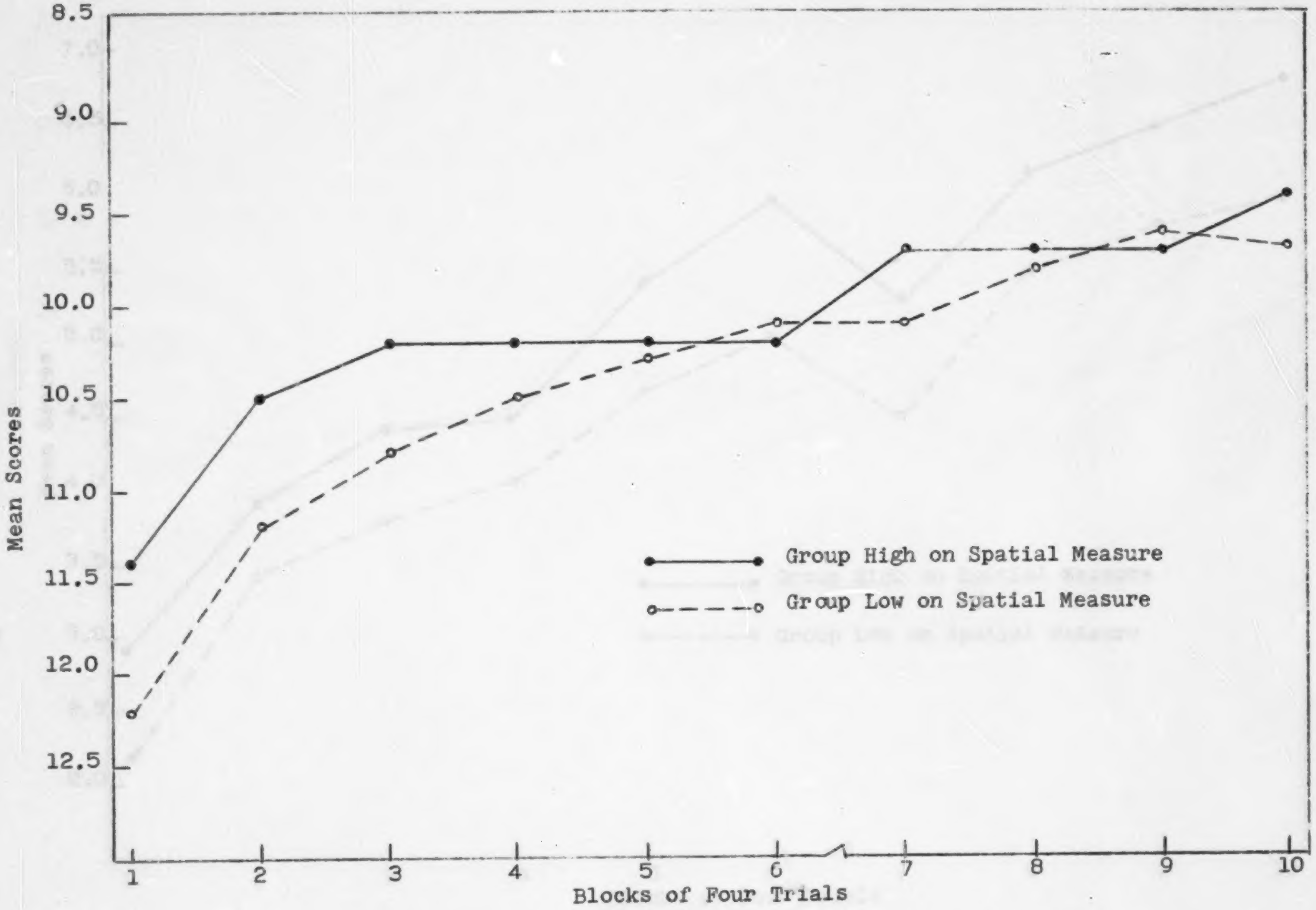

Fig. 1. Performance curves for Problem 1: Spatial Orientation and Speed Pass.

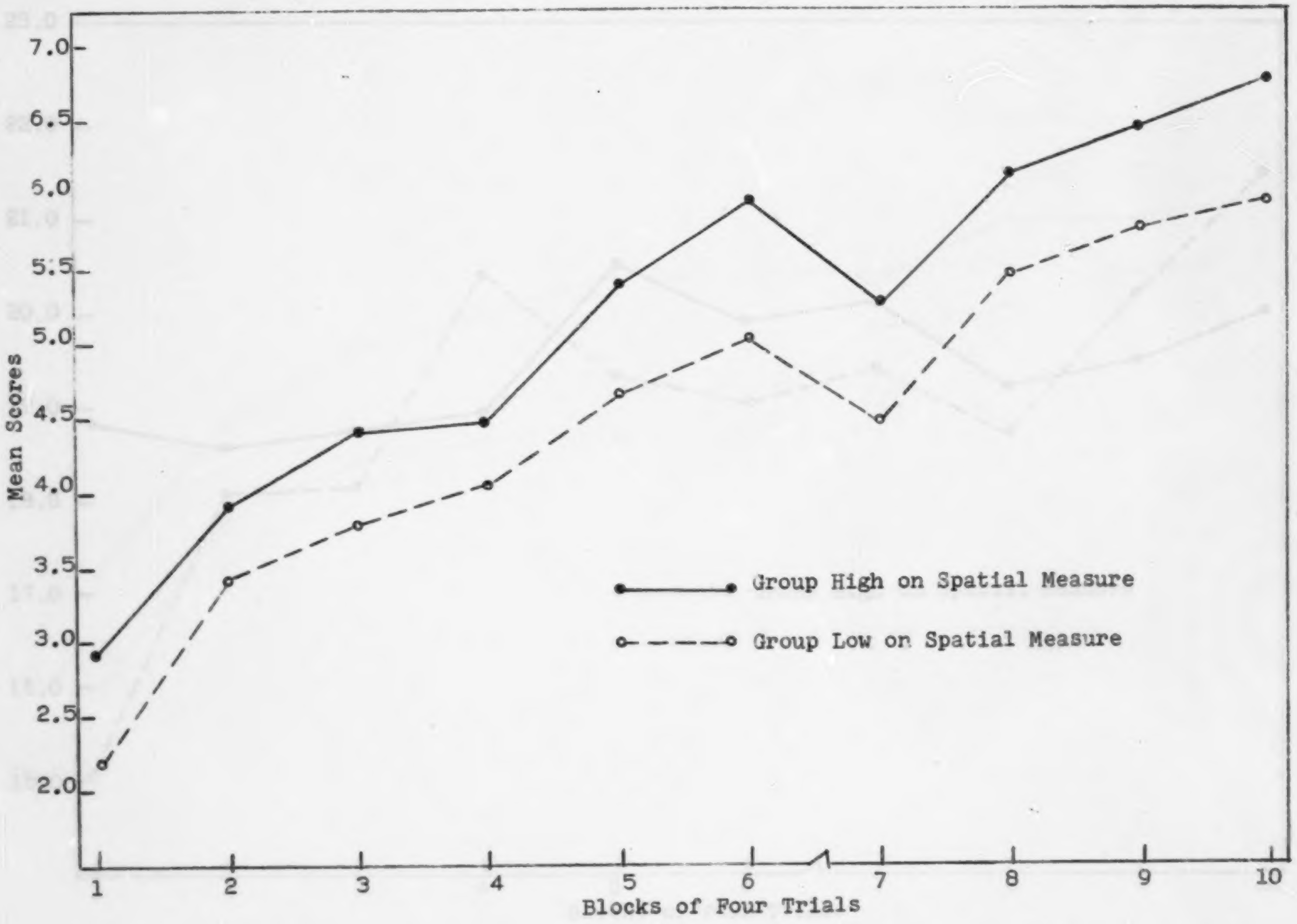

Fig. 2. Performance curves for Problem 2: Spatial Orientation and Balance Beam Stunt.

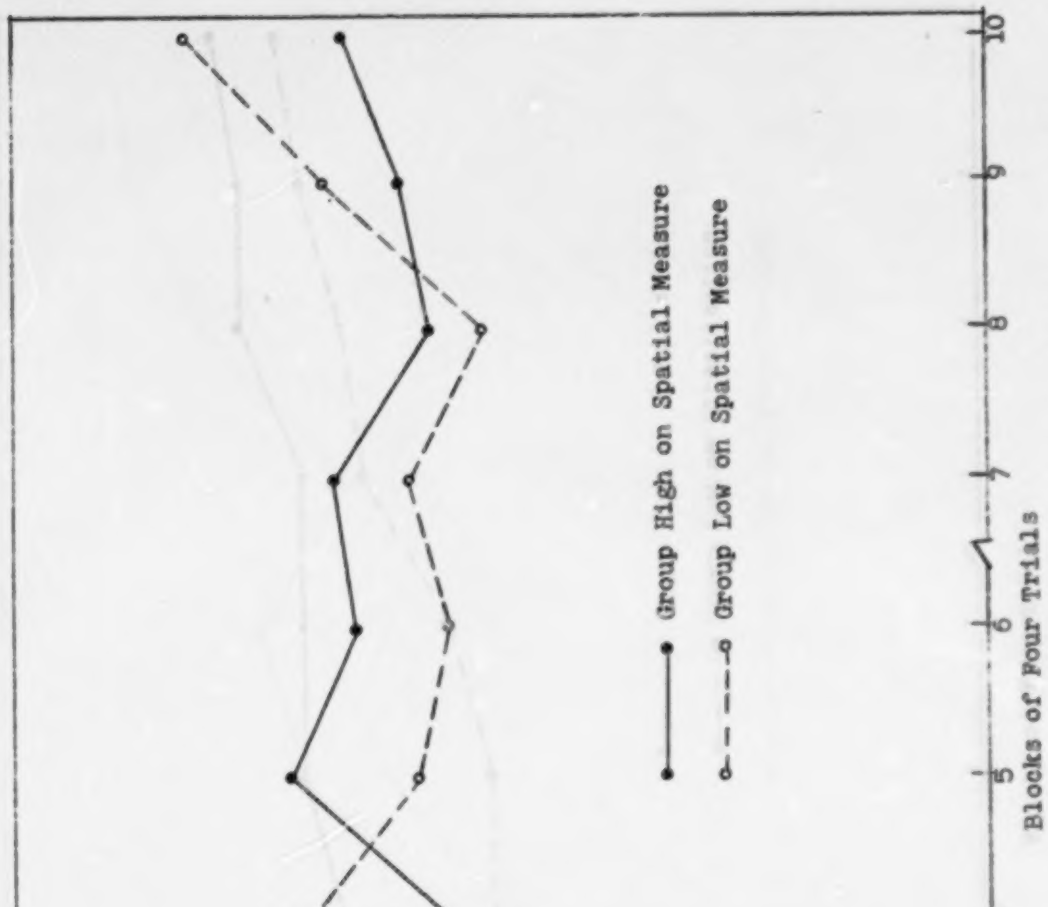

Fig. 3. Performance curves for Problem 3: Spatial Orientation and Underhand Throw.

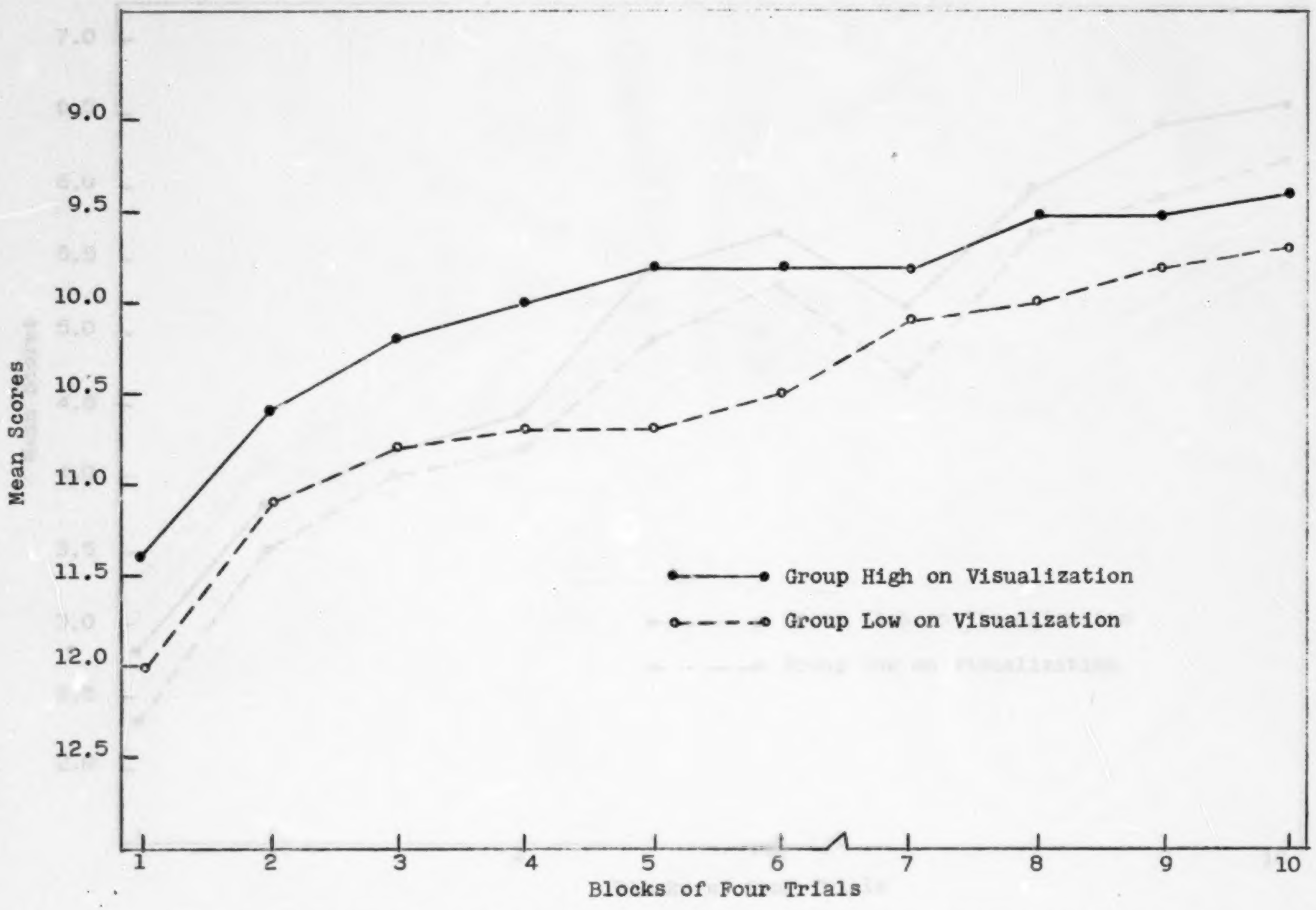

Fig. 4. Performance curves for Problem 4: Visualization and Speed Pass.

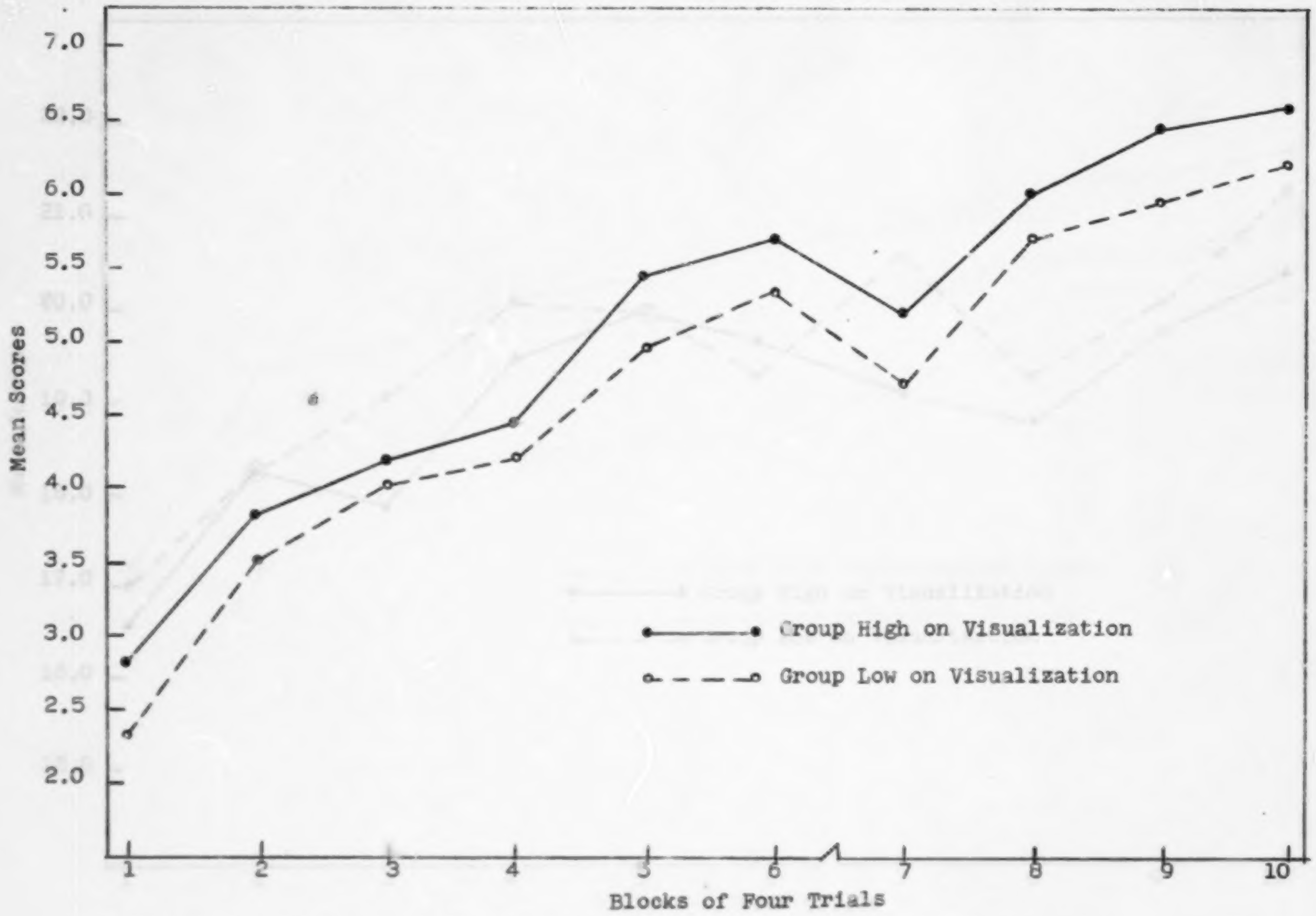

Fig. 5. Performance curves for Problem 5: Visualization and Balance Beam Stunt.

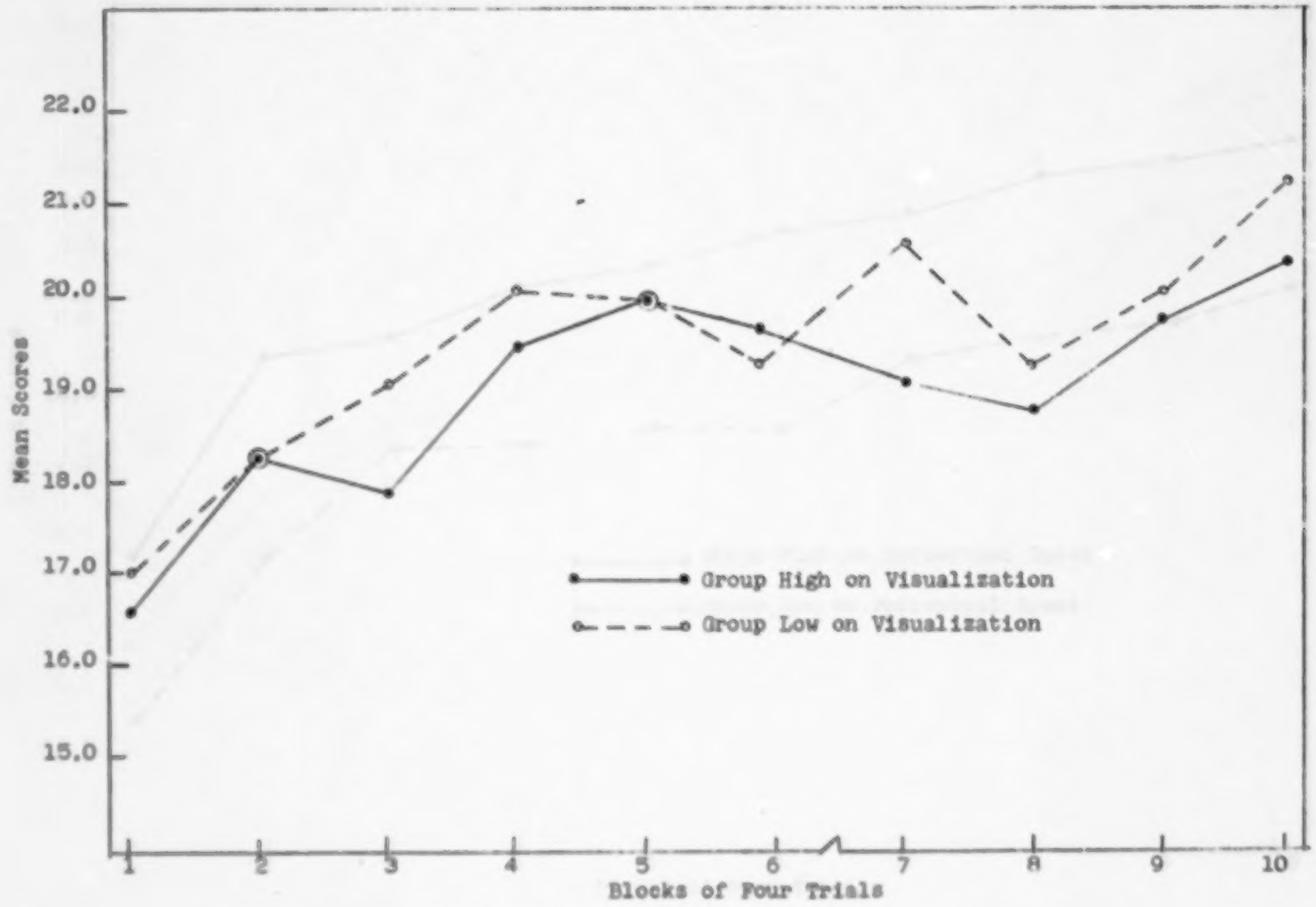

Fig. 6. Performance curves for Problem 6: Visualization and Underhand Throw.

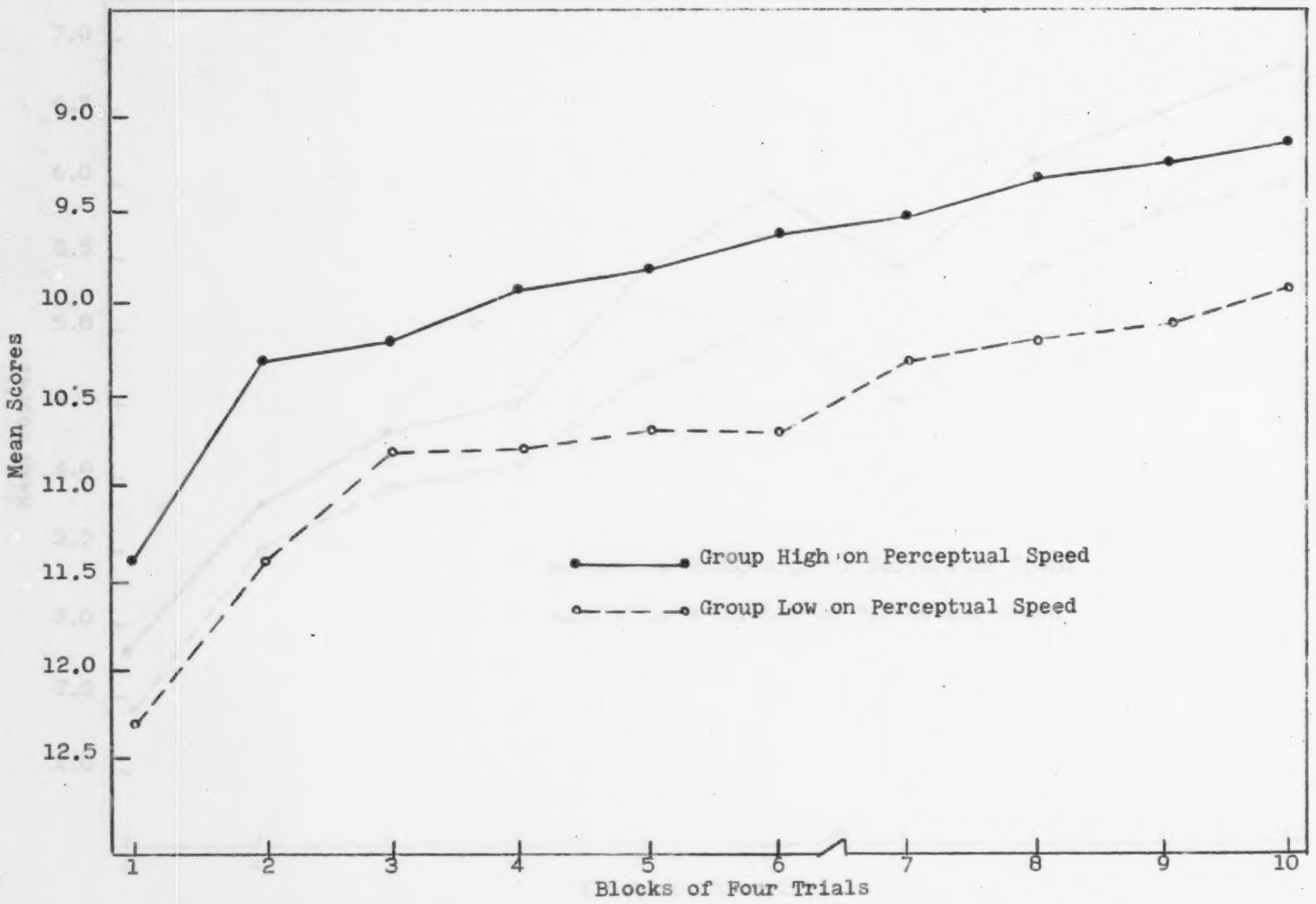

Fig. 7. Performance curves for Problem 7: Perceptual Speed andSpeed Pass.

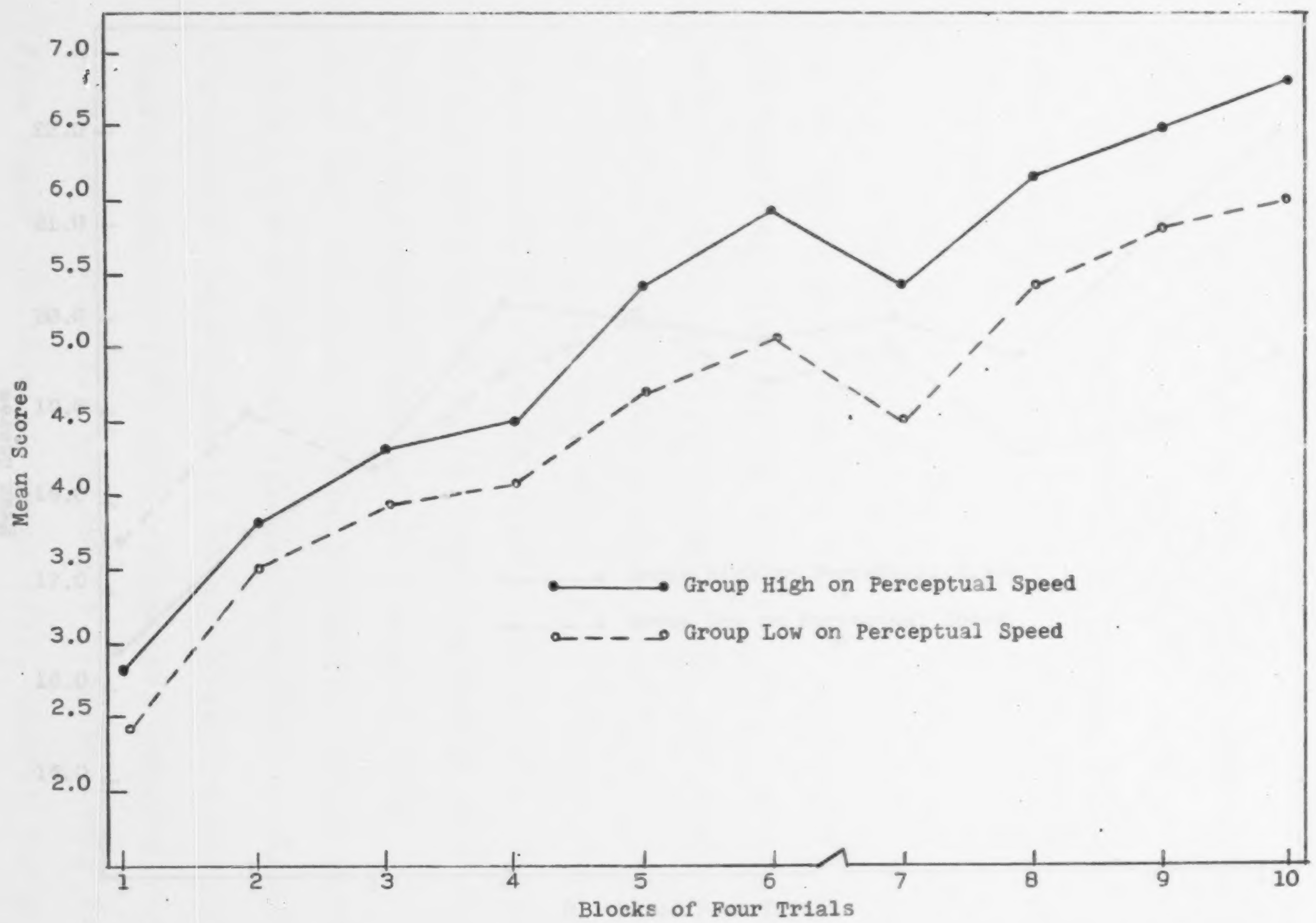

Fig. 8. Performance curves for Problem 8: Perceptual Speed and Balance Beam Stunt.

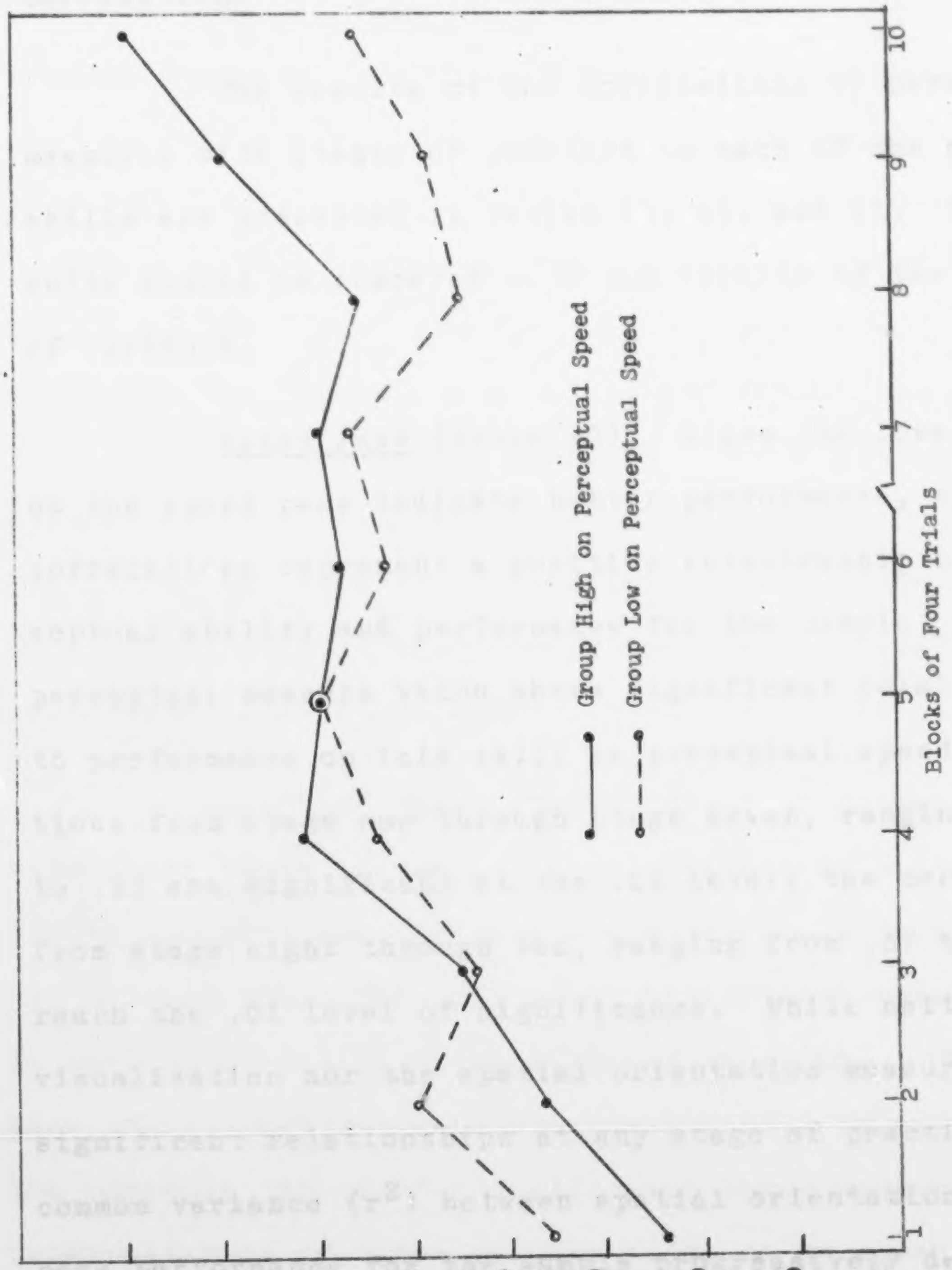

Fig. 9. Performance curves for Problem 9: Perceptual Speed and Underhand Throw.

Correlations

The results of the correlations of perceptual measures with stages of practice on each of the motor skills are presented in Tables 10, 11, and 12. These results should be compared with the results of the analyses of variance.

Speed Pass (Table 10). Since the lower scores on the speed pass indicate better performance, the negative correlations represent a positive relationship between perceptual ability and performance for the sample. The only perceptual measure which shows significant relationships to performance on this skill is perceptual speed. Correlations from stage one through stage seven, ranging from .27 to .33 are significant at the .05 level; the correlations from stage eight through ten, ranging from .37 to .40, reach the .01 level of significance. While neither the visualization nor the spatial orientation measure shows significant relationships at any stage of practice, the common variance (r^2) between spatial orientation and speed pass performance for the sample progressively decreases from stage one through stage nine, except for a slight increase at stage seven.

Balance Beam Stunt (Table 11). All three perceptual measures show significant relationships to performance on this skill. The coefficients for spatial orientation and visualization are significant throughout the stages of practice with no discernible change in variance over the period of practice. The coefficients are .41 and .39 at stage one for spatial orientation and visualization respectively and .39 and .49 at stage 10. Correlations of perceptual speed with performance are significant at stages one, three and four at the .05 level; they range from .27 to .31. At stages five through ten, the correlations are significant at the .01 level, ranging from .35 to .44.

Underhand Throw (Table 12). The correlations with perceptual speed increase fairly steadily from .09 at stage one to .40 at stage ten, and are significant from stages six through ten. The only other significant correlation is that with spatial orientation at stage one. The appearance of intermittent negative correlations is attributed to the variable nature of the underhand throw measure and any interpretation of these results needs to be made in terms of this variability.

Table 10

Correlations of Perceptual Measures with Successive Blocks of Four Trials on Speed Pass

Blocks of Trials	Spatial Orientation	Visualization	Perceptual Speed
1	-.23	-.21	-.27
2	-.21	-.22	-.31
3	-.18	-.20	-.17
4	-.19	-.26	-.31
5	-.15	-.30	-.33
6	-.08	-.25	-.30
7	-.14	-.19	-.27
8	-.05	-.17	-.39
9	-.05	-.17	-.39
10	-.16	-.23	-.37

Note: $r > .256$ $p < .05^a$
$r > .357$ $p < .01^a$

[a] Fisher's Table V.A. in Edwards, 1960, p. 362.

Table 11

Correlations of Perceptual Measures with Successive Blocks of Four Trials on Balance Beam Stunt

Blocks of Trials	Spatial Orientation	Visualization	Perceptual Speed
1	.41	.39	.31
2	.33	.27	.21
3	.39	.38	.30
4	.25	.32	.27
5	.40	.47	.40
6	.50	.48	.36
7	.54	.49	.44
8	.40	.46	.41
9	.40	.51	.37
10	.41	.49	.35

Note: $r > .256 \quad p < .05$[a]
$r > .357 \quad p < .01$[a]

[a] Fisher's Table V.A. in Edwards, 1960, p. 362

Table 12

Correlations of Perceptual Measures with Successive Blocks of Four Trials on Underhand Throw

Blocks of Trials	Spatial Orientation	Visualization	Perceptual Speed
1	.26	.13	.09
2	.11	.01	.06
3	-.02	-.06	.20
4	-.15	-.08	.26
5	.16	.03	.18
6	.19	.15	.27
7	.17	-.07	.29
8	.02	.02	.30
9	-.06	-.04	.40
10	-.07	-.11	.40

Note: $r > .256 \quad p < .05$[a]
$r > .357 \quad p < .01$[a]

[a] Fisher's Table V.A. in Edwards, 1960, p. 362

CHAPTER VI

DISCUSSION AND IMPLICATIONS

Statements based on the present investigation regarding the role of visual-spatial abilities in the performance of the skills studied need to be qualified. The data presented apply only to college women between the ages of 17 and 24. Since both sex and age have been noted as factors in visual-spatial ability (Fruchter, 1954), the data in this study are solely descriptive and can be applied only to samples similar to the one used.

Comparisons of results with previous studies would be desirable if data were comparable. However, the only studies found which have investigated the role of visual-spatial abilities in the performance of motor skills at different stages of practice are those of Fleishman and his collegues (Fleishman & Hempel, 1954, 1955; Fleishman & Rich, 1963). Reference is made to these studies where applicable.

Spatial Orientation

As hypothesized, the spatial orientation dichotomy had a significant effect on performance of all the skills in the early stages of practice. However, no stage effect was found in the performance of the balance beam stunt; the "high" group maintained a significant superiority throughout the practice period, with no observable change in the difference between groups at any particular stage. On finding a significant correlation between depth perception and balance, Miller (1960) suggested that the tests of these abilities had a visual element in common and that vision was an important factor in balance. The results of the present study support this assumption. How much of the visual requirement of balance activities is attributable to spatial orientation as such is a problem for future investigation.

The spatial orientation dichotomy produced a significant effect on speed pass performance during the first three stages of practice, with the "high" group maintaining superiority. These results are very similar to those reported by Fleishman and Rich (1963). In a study of a two-hand coordination task, they found that the "high" group excelled during the first three stages of a ten-stage practice period. In the task studied, the subject attempted to keep a target-follower on a small target disc as the target moved irregularly and at various rates around a circular plate. Movement of the target-follower to the right and left was controlled by one handle; forward and backward movement by another. Thus, simultaneous rotation of both handles moved the follower in any resultant direction. The possibility of "task similarity" between this skill and the speed pass used in the present study should be noted. In addition, while the results of the analysis of spatial orientation and underhand throw performance must be evaluated in terms of the variability of the test, the fact that the single significant difference between groups occurred at stage one is difficult to attribute to test variability alone. Thus, it would seem that at least three motor skills involving two-hand coordination have been shown to have significant relationships to spatial orientation ability in the early stages of learning.

The progressive decrease in the relationship of spatial orientation to speed pass performance as observed in this study is consistent with the results of factor analytic studies of manipulative motor skills (Fleishman & Hempel, 1954, 1955).

Visualization

The analyses of variance did not indicate any significant effects of the visualization dichotomy on performance of any of the skills tested nor was any stage effect found. These results are in contrast to the results of the correlation analysis. Comparison of the correlations for spatial orientation and visualization on each of the motor skills (Tables 10, 11, and 12) reveals striking simularities. It is suggested that the relatively high correlations that exist between tests of spatial orientation and visualization (Buros, 1953, pp. 693-698) are responsible for this simularity. It is also suggested that the difference in the results obtained by the two methods might be attributable to the fact that the correlations represent between-subject variances while in the analyses of variance, the subjects have been dichotomized on the perceptual measure.

In the present study, visualization, as measured, appears to have no appreciable effect on the performance of the skills tested. Further study of the relationship of visualizationto spatial orientation would seem desirable.

Perceptual Speed

The hypothesis that perceptual speed has a significant effect on performance throughout the period of practice would seem to be supported by the results of this study and is consistent with the factor analytic studies of Fleishman and Hempel (1954, 1955). While the effect was barely negligible in the case of the speed pass, it was substantial in the performance of the balance beam stunt.

The appearance of a stage effect in the performance of the balance beam stunt is difficult to interpret. Both the analysis of variance and the correlations suggest that perceptual speed may contribute more to the performance of this activity in the later stages of practice than in the early stages. Although significant differences between the "high" and "low" groups appeared throughout the period of practice, the data suggest a sudden increase in these differences at about the midpoint of the practice schedule. Possible explanations for this must await further investigation.

Methods of Analysis

Perhaps one of the most important observations to be made in this study is the relative efficacy of the methods used to treat the data. Comparison of the correlations (Tables 10, 11, and 12) with the corresponding analysis of variance problems suggests that in some cases intergroup differences, as represented by the dichotomy of subjects on the perceptual measure, produce more significant results than the intersubject differences represented in the correlations. If this is the case, then it might indicate that a minimal level of visual-spatial ability is necessary in the performance of these skills and that further variation among individuals is not effective in producing greater differences in performance. However, other alternatives are possible. Levels of ability lying intermediate to the intersubject and intergroup differences may be effective. In addition, the fact that the results of the two methods show striking similarities in some cases suggests that the effectiveness of different levels of ability may vary with the motor skill and even with the perceptual ability being studied. Investigation of these possibilities would seem to be a fruitful area for research.

Implications

While the relationships of visual-spatial abilities to performance of the skills has been shown to be relatively small, significant effects on performance have been found. It is assumed that these effects would be even more significant if tests of dynamic space perception were used. An important task for current researchers in the field of motor learning is the construction of such measures.

A study by Parker and Fleishman (1961) suggests that if, in the training situation, students are made aware of the ability requirements of a skill as these change over the period of learning, significant improvement in both performance and learning might be achieved. Unfortunately, little is currently known about the changes that occur in different gross motor skills. It is suggested that comprehensive factor analyses of different gross motor skills over the period of learning would be a fruitful and expedient method of filling this void. It is hoped that the present study will provide an incentive for such investigations.

However, application of the results of the study to the training situation need not await more comprehensive analyses. The results of the study by Parker and Fleishman (1961) demonstrate that emphasis on the spatial relationships involved in a skill, at the appropriate stage of learning, has a potential for improving performance. The present study suggests that these results might be applicable to certain gross motor skills as well.

The suggestion is also made that investigation of the relationship of visual-spatial ability to improvement as a result of "mental practice" might help illuminate the nature of the psychological processes involved in both. If "mental practice" is, in fact, a method of emphasizing the spatial relationships of a skill, then the efforts of investigators in both areas might be combined to effect more fruitful results.

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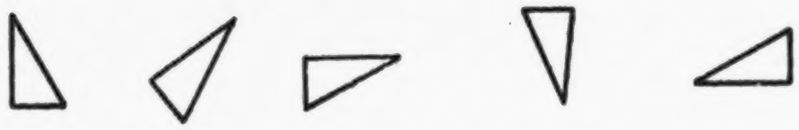
APPENDIX A

PERCEPTUAL TESTS

Name: ______________________________

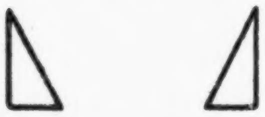
CARD ROTATIONS TEST — S-1

This is a test of your ability to see differences in figures. Look at the 5 triangle-shaped cards drawn below.



All of these drawings are of the same card, which has been slid around into different positions on the page.

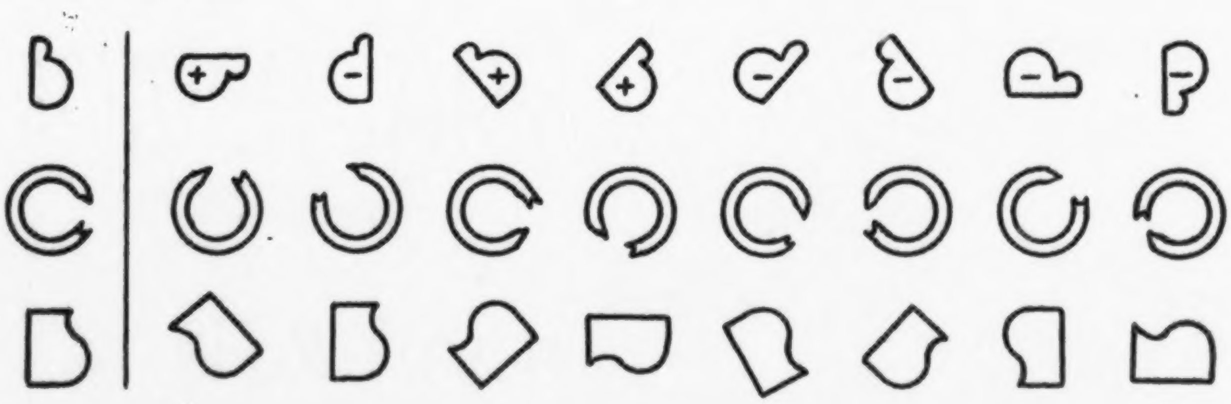
Now look at the 2 cards below:



These two cards are not alike. The first cannot be made to look like the second by sliding it around on the page. It would have to be flipped over or made differently.

Each problem in this test consists of one card on the left of a vertical line and eight cards on the right. You are to decide whether each of the eight cards on the right is the same as or different from the card at the left. Put a plus (+) or cross (X) on the card, if it is the same as the one at the beginning of the row. Put a minus (—) on the card, if it is different from the one at the beginning of the row.

Practice on the following rows. The first row has been correctly marked for you.



Your score on this test will be the number of cards marked correctly minus the number marked incorrectly. Therefore, it will not be to your advantage to guess, unless you have some idea whether the card is the same or different. Work as quickly as you can without sacrificing accuracy.

You will have 4 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

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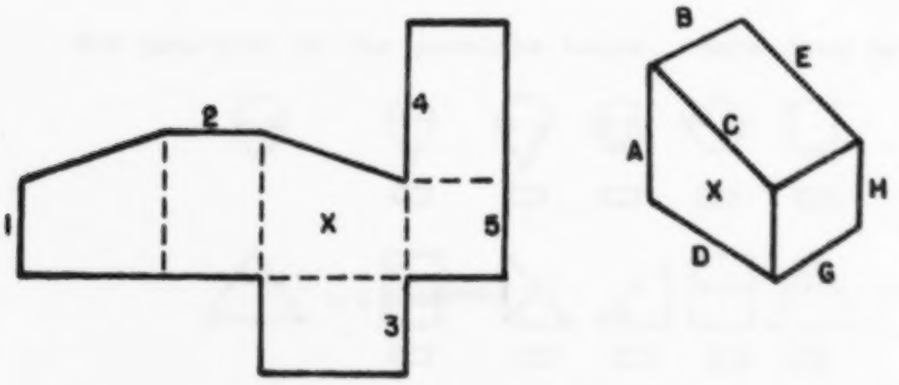
Suggested by Cards by L. L. Thurstone

Name: ____________________

SURFACE DEVELOPMENT TEST — Vz-3

In this test you are to try to imagine or visualize how a piece of paper can be folded to form some kind of object. Look at the two drawings below. The drawing on the left is of a piece of paper which can be folded on the dotted lines to form the object drawn at the right. You are to imagine the folding and are to figure out which of the lettered edges on the object are the same as the numbered edges on the piece of paper at the left. Write the letters of the answers in the numbered spaces at the far right.

Now try the practice problem below. Numbers 1 and 4 are already correctly marked for you.



1: H
2:
3:
4: C
5:

NOTE: The side of the flat piece marked with the X will always be the same as the side of the object marked with the X. Therefore, the paper must always be folded so that the X will be on the outside of the object.

In the above problem, if the side with edge 1 is folded around to form the back of the object, then edge 1 will be the same as edge H. If the side with edge 5 is folded back, then the side with edge 4 may be folded down so that edge 4 is the same as edge C. The other answers are as follows: 2 is B; 3 is G; and 5 is H. Notice that two of the answers can be the same.

Your score on this test will be the number of correct letters minus a fraction of the number of incorrect letters. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 6 minutes for each of the two parts of this test. Each part has 2 pages. When you have finished Part 1 (pages 2 and 3), STOP. Please do not go on to Part 2 until you are asked to do so.

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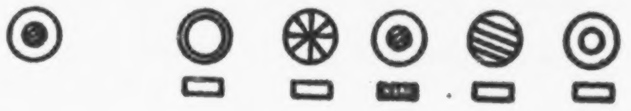
Adapted from Surface Development by L. L. Thurstone

Name: ______________________________

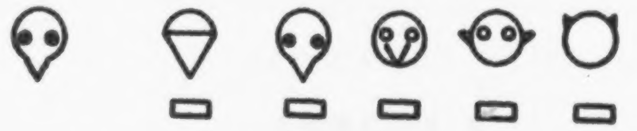
IDENTICAL PICTURES TEST — P-3

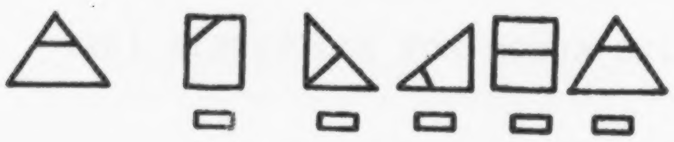
How fast can you match a given object? This is a test of your ability to pick the correct object quickly. At the left of each row is an object. To the right are five test objects one of which matches the object at the left. Look at the example below:

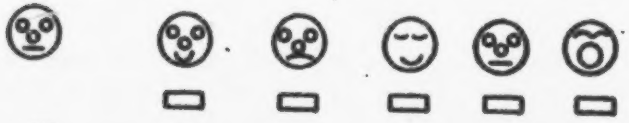


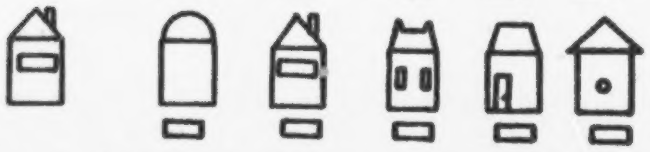
The third test object has been marked by blackening the space below it, because it is the same as the object at the left.

Now practice on the problems below. Mark them as fast as you can:









Your score on this test will be the number of objects marked correctly minus a fraction of the number marked incorrectly. Work as quickly as you can without sacrificing accuracy.

You will have 1 1/2 minutes for each of the two parts of this test. Each part has two pages. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

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Suggested by Identical Forms by L. L. Thurstone

APPENDIX B

TEST DIRECTIONS FOR MOTOR SKILLS

General Instructions for Students

1. Pick up a scorecard on entering the gymnasium; put your name and number at the top of the card.
2. Check the back of the card for your rotation schedule for the day.
3. Proceed immediately to your starting area for the day and line up for the demonstration as directed by the Assistant in that area.
4. Following the demonstration, begin the tests, following the procedures listed under Test Directions.
5. Repeat (3) and (4) above for each of the three tests. Rotate according to the schedule on the back of your scorecard when the signal to "rotate" is given.
6. Keep your scorecard in your shirt pocket except at designated time.
7. Do not give advice or assistance to other students on their performances; do not ask for advice or assistance on your performance.
8. If you have any questions on procedure, direct them to the Assistant in your area.
9. Turn in your scorecard before leaving the gymnasium; do not leave until the class is formally dismissed.
10. Do not practice skills between sessions, before, or after class or during class except when instructed to take tests by the Assistant.

Test Directions

SPEED PASS

1. Following the demonstration, sit facing the backdrop so that you cannot see the performances of others.
2. Check the back of your scorecard to find the order in which you are to perform.
3. As your number is called, move quickly to the testing area and hand your scorecard to the Recorder.
4. Take a position behind the restraining line with the ball.
5. At the signal "begin" from the Timer, pass the ball against the wall with a two-hand chest pass, as demonstrated, catch the ball, and continue passing until the Timer says "stop."
6. If you lose control of the ball, recover it yourself, return to a position behind the restraining line and continue passing until the Timer says "stop."
7. At no time during the trial may you step on or over the restraining line while passing the ball.
8. When your score for the first trial has been recorded, retrieve your scorecard and return to your seat facing the backdrop.

Test Directions (Continued)

9. Repeat as your number is called for your second trial. After your second trial, remain seated until the signal to "rotate" is given.

   Scoring: Your score for each trial is the time (to a tenth of a second) from the instant the first pass hits the wall until the tenth pass hits the wall.

UNDERHAND THROW

1. Following the demonstration, check the back of your scorecard to find your assigned basket and partner for the day; move quickly to your basket.
2. The person listed first on the scorecard hand card to the Scorer and take a position behind the restraining line with the ball.
3. At the signal "begin" from the Scorer, execute an underhand throw for the basket as demonstrated.
4. The partner sits so that you cannot see the performance of others.
5. Retrieve your own ball, return to a position behind the restraining line and repeat for a total of five throws.
6. Rotate with your partner and repeat (2) through (5) for a total of two trials of five throws each. Retrieve your scorecard after each trial.
7. As soon as all trials at the basket have been completed, leave the ball on the restraining line, sit so that you cannot see the performances of others and remain seated until the signal to "rotate" is given.

   Scoring: Your score for each trial is the sum of the scores recorded for each of the five throws of the trial. Each throw is scored on on the following basis:

   3 points - ball goes "cleanly" through basket
   2 points - basket is made, but ball hits rim or backboard
   1 point - basket is missed, but ball hits rim (or backboard and rim)
   0 points - anything not included in the above

STUNT

1. Following the demonstration, sit facing the wall so that you cannot see the performances of others.
2. Check the back of your scorecard to find the order in which you are to perform.
3. As your number is called, move quickly to the nearer end of the beam and be ready to hand your scorecard to the Recorder.

STUNT (continued)

4. On the signal "begin" from the Judge, mount the beam and execute the stunt as demonstrated.

5. If you lose your balance on one part of the stunt, step to the mat, remount, and proceed to the next part. Do not attempt to repeat the part you missed.

6. If you fail to perform a part of the stunt within a reasonable length of time, the Judge will ask you to "proceed to the next part."

7. Dismount when you have finished your first trial and wait for the Judge's signal to "repeat." At this signal, remount at the far end of the beam and repeat the stunt for your second trial.

8. Retrieve your scorecard from the Recorder, return to your seat facing the wall and remain seated until the signal to "rotate" is given.

Scoring: Your score for each trial is from 0 to 9 points as determined by the Judge on the following basis:

Execution - 1 point for each of the 6 parts of the stunt performed correctly.
General Impression - 1 point each for balance, continuity of movement, and posture.

APPENDIX C

INSTRUCTIONS TO ASSISTANTS

Instructions for Judge

(Stunt)

1. Bring counters (2) and Assignment Schedule to each session.

2. Supervise Recorders setting up balance beam and mats.

3. Assign four students to each side of the demonstration area so that all have an adequate view of your performance.

4. Begin your demonstration when the underhand throw demonstration begins.

5. During the demonstration, name the parts of the stunt (e.g., "walk forward three steps, pivot turn. . ." etc.) but do not otherwise describe the performance.

6. Following the demonstration, direct the group to sit facing the wall so that they cannot see the performances of others.

7. Give each student in turn the signal to "begin."

8. Score each trial from 0 to 9 points on the following basis, using the hand counter to tally points.
   a. Execution - one point for each of the six parts of the stunt performed correctly; a part is not correct if the student:
      (1) fails to perform a part within 3 seconds of the completion of the previous part. Call "proceed to the next part."
      (2) steps from the apparatus
      (3) fails to achieve a near parellel position on the Scale
      (4) touches the beam moving from the Pose to the Scale
      (5) fails to make a complete turn on the Jump or Pivot
      (6) fails to hold the arabesque or scale for at least 3 seconds
   b. General Impression- one point each for:
      (1) balance
      (2) continuity or flow
      (3) posture including head position and body bend.

9. When a student has finished her first trial, call score for the Recorder and ask her to repeat it aloud.

10. Signal student to "repeat" stunt for her second trial; call score for Recorder before signaling next student to "begin."

11. Set counter back after each trial.

12. Do not give advice or assistance to students on their performances.

13. Inform Miss Stallings immediately when all students in the group have completed their trials.

14. Repeat (3) through (13) for each of the three groups each session.

Instructions for Timer

(Speed Pass)

1. Bring stop watches (2), Assignment Schedule, and volleyball to each session.
2. Supervise Scorers in setting up backdrop.
3. Assign four students to each side of the demonstration area so that all have an adequate view of your demonstration.
4. Begin your demonstration when the underhand throw demonstration begins.
5. During the demonstration, name the pass ("two-hand chest pass"), but do not otherwise describe the performance.
6. Following the demonstration, direct the group to sit facing the backdrop so that they cannot see the performances of others.
7. Check the Assignment Schedule and call each student's number in the order designated for the day.
8. When the student is behind the restraining line with the ball, signal "ready . . . begin"; signal "stop" when the tenth pass hits the wall.
9. Start the watch when the first pass hits the wall; stop the watch when the tenth pass hits the wall. Start and stop the watch with the sound of the hit.
10. Call the score consistently the same way (e.g., "nine-point-four"). Ask the Recorder to repeat the score aloud.
11. Set the watch back before calling the next student.
12. If a pass is grossly incorrect (shoulder pass, underhand pass, or one-hand pass) stop the trial immediately and repeat it.
13. Do not give advice or assistance to students on their performances.
14. Inform Miss Stallings immediately when all students in the group have completed their trials.
15. Repeat (3) through (14) for each of the three groups each session.

Instructions for Scorers

(Underhand Throw)

1. Bring Assignment Schedule each day.
2. Pick up recording pen and volleyball from the Matron.
3. Set up the balance beam and mats before class (12:00 section) and return them after the last class (1:00 section).
4. Take assigned stations immediately after the demonstrations; place the ball on the restraining line.
5. Check the Assignment Schedule to see that the students at your basket are those assigned to it for that day.
6. The first number on the Assignment Schedule is tested first; take her scorecard and direct her to a position behind the restraining line with the ball.
7. Remind her partner to sit so that she cannot see the performance of others.
8. When both partners are in position, signal the student to "begin."
9. Score each throw on the following basis:

   3 points - ball goes "cleanly" through basket
   2 points - basket is made, but ball hits rim or backboard
   1 point - basket is missed, but ball hits rim (or backboard and rim)
   0 points - anything not included in the above

10. If the ball is not thrown with both hands underhanded, disregard the throw and have the student repeat it.
11. Score each of the five throws of a trial legibly in the appropriate box. Do not sum the scores.
12. Return the scorecard after each trial. Do not take the scorecard of a waiting student until you have returned the card of the person being tested.
13. Have the partners rotate after each trial of five throws for a total of two trials each.
14. After completion of the trials, direct the partners to "sit" so that they cannot see the performances of others. Inform Miss Stallings that the trials at your basket are completed.
15. Do not give advice or assistance to students on their performance. If you have questions, call Miss Stallings to your area before proceeding with the tests.
16. Do not leave the gymnasium until the class is formally dismissed; return recording pen to the Matron.

Instructions for Recorders

(Stunt and Speed Pass)

GENERAL

1. Bring Assignment Schedule each day.
2. Pick up recording pen from the Matron.
3. Set up the backdrop before class (12:00 section) and return it after the last class (1:00).
4. Take assigned stations immediately after the demonstrations.
5. Record the score for each trial legibly in the appropriate box; repeat the score aloud.
6. Do not give advice or assistance to students on their performances. If you have questions, check with Miss Snodgrass (stunt) or Miss Murfitt (speed pass) immediately.
7. Do not leave the gymnasium until the class is formally dismissed; return recording pen to the Matron.

SPEED PASS

1. The Timer will call each student by number in their order for the day. Take student's scorecard and direct her to a position behind the restraining line with the ball.
2. Watch student's feet for line violations (stepping on or over the line while passing the ball).. Record "L" above the score for any trial where a line violation occurs. Inform the student after the trial that she has committed a line violation.
3. Repeat aloud the score called by the Timer (e.g., "nine-point-four ").
4. Return the scorecard after each trial and direct the student to return to her seat facing the backdrop.

STUNT

1. Check Assignment Schedule for the order of performance for the day and call the proper number each time the Judge says "repeat."
2. Do not take the scorecard of the waiting student until you have returned the card of the person being tested.
3. Repeat aloud the score called by the Judge.
4. After each student has completed her two trials, return her scorecard and direct her to return to her seat facing the wall.

APPENDIX D

MOTOR SKILLS TEST SCORECARD

No.______ Name________________

		Trial	
UNDERHAND THROW		1st	2nd
3 pts. - "clean" basket 2 pts. - basket made & ball hits rim or backboard 1 pt. - basket missed & ball hits rim 0 pts. - basket missed & ball fails to hit rim	# 1		
	# 2		
	# 3		
	# 4		
	# 5		
SPEED PASS		1st	2nd
Time to tenth of a second (e.g., 9.4)			
STUNT		1st	2nd
1 to 9 points as called by Judge			

Date ___/___/65

GROUP ROTATION SCHEDULE

Underhand Throw - Stunt - Speed Pass

Speed Pass - Underhand Throw - Stunt

Stunt - Speed Pass - Underhand Throw

PARTNER SCHEDULE & BASKET ASSIGNMENT

# with # at Basket # 1
# with # at Basket # 2
# with # at Basket # 3
# with # at Basket # 4

ORDER FOR SPEED PASS & STUNT:

Back - Group Rotation Schedule #1

Date ___/___/___

GROUP ROTATION SCHEDULE

Underhand Throw - Speed Pass - Stunt

Speed Pass - Stunt - Underhand Throw

Stunt - Underhand Throw - Speed Pass

PARTNER SCHEDULE & BASKET ASSIGNMENT

# with # at Basket # 1
# with # at Basket # 2
# with # at Basket # 3
# with # at Basket # 4

ORDER FOR SPEED PASS & STUNT:

Back - Group Rotation Schedule #2

APPENDIX E

ROTATION SCHEDULES

GROUP ROTATION SCHEDULE

DATES	GROUPS		
	A and D	B and E	C and F
Fri., Feb. 26	UT-SP-S	SP-S-UT	S-UT-SP
Mon. Mar. 1	SP-S-UT	S-UT-SP	UT-SP-S
Fri., Mar. 5	S-UT-SP	UT-SP-S	SP-S-UT
Mon. Mar. 8	UT-S-SP	SP-UT-S	S-SP-UT
Fri. Mar. 12	SP-UT-S	S-SP-UT	UT-S-SP
Mon. Mar. 15	S-SP-UT	UT-S-SP	SP-UT-S
Fri., Mar. 19	UT-SP-S	SP-S-UT	S-UT-SP
Mon. Mar. 22	SP-S-UT	S-UT-SP	UT-SP-S
Fri. Mar. 26	S-UT-SP	UT-SP-S	SP-S-UT
Mon. Mar. 29	UT-S-SP	SP-UT-S	S-SP-UT
Fri. Apr. 2	SP-UT-S	S-SP-UT	UT-S-SP
Mon. Apr. 5	S-SP-UT	UT-S-SP	SP-UT-S
Fri. Apr. 23	UT-SP-S	SP-S-UT	S-UT-SP
Mon. Apr. 26	SP-S-UT	S-UT-SP	UT-SP-S
Fri. Apr. 30	S-UT-SP	UT-SP-S	SP-S-UT
Mon. May 3	UT-S-SP	SP-UT-S	S-SP-UT
Fri. May 7	SP-UT-S	S-SP-UT	UT-S-SP
Mon. May 10	S-SP-UT	UT-S-SP	SP-UT-S
Fri. May 14	UT-SP-S	SP-S-UT	S-UT-SP
Mon. May 17	SP-S-UT	S-UT-SP	UT-SP-S

Key: UT - underhand throw
SP - speed pass
S - balance beam stunt

ORDER FOR STUNT AND SPEED PASS

Dates	ORDER							
	1st	2nd	3rd	4th	5th	6th	7th	8th
February 26	1	3	5	7	8	6	4	2
March 1	2	4	6	8	1	7	5	3
March 5	3	5	7	1	2	8	6	4
March 8	4	6	8	2	3	1	7	5
March 12	5	7	1	3	4	2	8	6
March 15	6	8	2	4	5	3	1	7
March 19	7	1	3	5	6	4	2	8
March 22	8	2	4	6	7	5	3	1
March 26	1	3	5	7	8	6	4	2
March 29	2	4	6	8	1	7	5	3
April 2	3	5	7	1	2	8	6	4
April 5	4	6	8	2	3	1	7	5
April 23	5	7	1	3	4	2	8	6
April 26	6	8	2	4	5	3	1	7
April 30	7	1	3	5	6	4	2	8
May 3	8	2	4	6	7	5	3	1
May 7	1	3	5	7	8	6	4	2
May 10	2	4	6	8	1	7	5	3
May 14	3	5	7	1	2	8	6	4
May 17	4	6	8	2	3	1	7	5

BASKET ASSIGNMENTS

Dates	Basket Number			
	No. 1	No. 2	No. 3	No. 4
February 26	1&2	8&3	7&4	6&5
March 1	4&5	3&6	2&7	8&1
March 5	7&3	5&1	6&4	2&8
March 8	8&7	6&2	3&5	4&1
March 12	1&6	5&7	4&8	2&3
March 15	8&5	4&2	3&1	6&7
March 19	4&3	7&1	8&6	2&5
March 22	2&1	3&8	4&7	5&6
March 26	5&4	6&3	7&2	1&8
March 29	3&7	1&5	4&6	8&2
April 2	7&8	2&6	5&3	1&4
April 5	6&1	7&5	8&4	3&2
April 23	5&8	2&4	1&3	7&6
April 26	3&4	1&7	6&8	5&2
April 30	1&2	8&3	7&4	6&5
May 3	4&5	3&6	2&7	8&1
May 7	7&3	5&1	6&4	2&8
May 10	8&7	6&2	3&5	4&1
May 14	1&6	5&7	4&8	2&3
May 17	8&5	4&2	3&1	6&7

APPENDIX F

GROUP MEANS USED IN COMPARISONS AND IN PLOTTING PERFORMANCE CURVES

GROUP MEANS

Group	STAGES OF PRACTICE 1	2	3	4	5	6	7	8	9	10
Problem 1 (Spatial Orientation and Speed Pass)										
High	11.41	10.45	10.20	10.20	10.15	10.24	9.68	9.67	9.68	9.42
Low	12.23	11.21	10.80	10.47	10.31	10.11	10.14	9.84	9.57	9.67
Problem 2 (Spatial Orientation and Balance Beam Stunt)										
High	2.88	3.92	4.36	4.46	5.43	5.95	5.38	6.15	6.50	6.76
Low	2.24	3.36	3.78	4.10	4.73	5.05	4.51	5.50	5.79	6.05
Problem 3 (Spatial Orientation and Underhand Throw)										
High	18.95	18.57	18.76	19.04	20.61	19.95	20.23	19.33	19.61	20.14
Low	15.09	18.09	18.19	20.52	19.42	19.09	19.52	18.76	20.33	21.57

GROUP MEANS

Group	STAGES OF PRACTICE 1	2	3	4	5	6	7	8	9	10
Problem 4 (Visualization and Speed Pass)										
High	11.62	10.57	10.24	9.96	9.77	9.80	9.76	9.54	9.46	9.35
Low	12.02	11.09	10.75	10.71	10.69	10.54	10.06	9.97	9.79	9.69
Problem 5 (Visualization and Balance Beam Stunt)										
High	2.79	3.80	4.19	4.38	5.35	5.73	5.19	5.98	6.39	6.64
Low	2.33	3.48	3.96	4.18	4.81	5.27	4.70	5.67	5.90	6.18
Problem 6 (Visualization and Underhand Throw)										
High	16.61	18.33	17.85	19.47	20.00	19.71	19.14	18.80	19.80	20.38
Low	17.42	18.33	19.09	20.09	20.04	19.33	20.61	19.28	20.14	21.33

GROUP MEANS

Group	STAGES OF PRACTICE 1	2	3	4	5	6	7	8	9	10
Problem 7 (Perceptual Speed and Speed Pass)										
High	11.35	10.29	10.22	9.90	9.75	9.64	9.53	9.26	9.20	9.10
Low	12.29	11.38	10.77	10.77	10.71	10.71	10.28	10.24	10.05	9.94
Problem 8 (Perceptual Speed and Balance Beam Stunt)										
High	2.76	3.81	4.30	4.48	5.43	5.91	5.37	6.24	6.54	6.80
Low	2.37	3.46	3.85	4.08	4.73	5.09	4.52	5.41	5.75	6.02
Problem 9 (Perceptual Speed and Underhand Throw)										
High	16.42	17.66	18.52	20.19	20.04	19.71	20.04	19.57	21.09	22.04
Low	17.61	19.00	18.42	19.38	20.00	19.33	19.71	18.52	18.85	19.66

VITA

Loretta May Stallings was born in San Diego, California on December 12, 1925, the daughter of Helen Myrtle Stallings and Robert H. Stallings. After completing her studies at San Diego High School in 1943, she entered Stanford University, Palo Alto, California. She received the degree of Bachelor of Arts with a major in physical education from Stanford University in June, 1947. For the following two years, she was employed as a physical education teacher at Lodi High School, Lodi, California, during which time she undertook graduate study at the College of the Pacific, Stockton, California. She was awarded the degree of Master of Arts with a major in health education in January, 1950, while serving as Chairman of Physical Education at Franklin High School, Stockton. From 1952 until 1954, she was employed as the health and physical education teacher at St. Mary's Junior College, St. Mary's City, Maryland. From 1954 until 1960, she was Instructor and then Assistant Professor of Physical Education at The George Washington University, Washington, D.C., where she is currently Associate Professor and Chairman of the Department of Physical Education for Women.

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